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JUNE, 1912 BULLETIN 315

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Plant Pathology

FUNGOUS FLORA OF THE SOIL

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ITHACA, N. Y.
PUBLISHED BY THE UNIVERSITY

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FUNGOUS FLORA OF THE SOIL*

C. N. Jensen

For many years the fungous flora of the soil has attracted considerable attention from various points of view. From a purely systematic standpoint, little has been known until recently of the species constituting a part of this flora, and little has been known of its biology and physiology. The present work is the outcome of investigations begun with a view to determine the extent of distribution of known pathogens in the soil and of their ease of isolation by cultural methods. Hence the systematic study and technic have been emphasized with a view to paving the way for more fertile biological and biochemical studies, as well as to serve as a basis for a monograph of the soil fungi.

The fungous inhabitants of the soil may properly be classified as obligate saprophytes and facultative parasites. In the determination of the obligate saprophytic forms, we must resort to the isolation of the forms by cultural methods only, while the determination of the facultative parasites may be carried on in two ways: one by isolation, the same as with the obligate saprophytes, and after isolation the determination of the pathogenicity of the form in question by a series of inoculations on the presumable host; the other, the reciprocal of this, by growing crops under controlled conditions and, in case disease due to parasitic fungi arises, in isolating the causal organism from the host.

The isolation of fungi from the soil is not so simple a task as at first sight it might appear. While it is true that we must consider the fungous flora of the soil as consisting of saprophytes, it does not follow that all these fungi will yield to one and the same cultural method or that they will grow on similar media. There must be a certain specialization as to food relations, temperature, moisture, oxygen, and so forth, with saprophytes as well as with parasites. This specialization must exist *a priori* in various degrees.

Every amateur student in mycology or plant pathology knows that if he wishes to collect a Pilobolus, a Sordaria, or a Chaetomium, he is most likely to find it on dung; in order to find *Pyronema confluens*, he looks for it on burned areas; again, certain saprophytes, such as the Cytosporas, grow commonly on dead twigs of the stone fruits, Salix, Populus, and the like. This specialization is recognized well in classification, as we often find groups of fungi designated by such words as fimicole, lignicole, caulicole, and so on. This being accepted without question, how readily

*Also presented before the Faculty of the Graduate School of Cornell University January 19, 1912, as a major thesis in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

should we expect to meet with considerable difficulty in isolating soil fungi, because of the lack of suitable media and other environmental factors! The acidity or alkalinity of the media, the kind of media as to nitrogen source, carbon source, and so forth, temperature, moisture, supply of oxygen, and various other factors determine to what extent cultural work ends in success.

Again, difficulty arises in taking the soil sample and in subsequently handling it so that contaminations are practically eliminated. There is no reason to presume that a fungus living saprophytically in the soil may not live elsewhere; in fact, the contrary is now known to be the case. If we are to speak of the fungous flora of the soil, no species should be grouped here unless evidence sufficient to substantiate the statement is at hand, because in this connection we are dealing with the very important item of habitat.

HISTORICAL

With the foregoing brief statements of some of the principal difficulties confronting the investigator of soil fungi, it has seemed desirable to give an historical review of the technic employed by previous workers in this field, together with their results, before taking up for consideration the writer's individual work.

Prior to 1886 there is practically nothing worthy of our attention, so far as isolation of soil fungi is concerned. Before that date it was generally recognized that the soil contained many of the lower fungi, but that was about the extent of the knowledge at that time. As to descriptions of species, there were probably very few of any value.

Adametz ('86) was the first real investigator who attempted to isolate soil forms and to give them names and descriptions. He isolated bacteria, yeasts, and molds, but we are interested only in that he isolated eleven fungi, among which were four yeasts (including *Monilia candida*). The purpose of his isolations was to obtain species for biochemical studies.

The soil samples used for his isolation work represented both sandy and loamy tilled land of the experimental fields. One sample was taken at the surface, and a second directly beneath at a depth of 25 to 30 cm. The original plan was to keep the fungi, isolated from the two kinds of soil, separate; but after some time this idea was abandoned because he found that the two soils harbored the same species.

The sterilized reagent flasks (including sterile media presumably, although this is not stated), closed with sterilized cotton plugs, were inoculated in the field where the samples were taken. Further details

('86) Adametz, Leopold. Untersuchungen u. d. Niederen Pilze der Ackerkrume. Inaug. Diss. 1–78. *pl.* 2. 1886.

with respect to taking the samples are not given, except the statement that the greatest precaution in all the work was constantly observed. The methods observed in sterilization of media, glassware, etc., were similar to those of Hueppe ('85), whom he followed closely.

Following Adametz we find Reinitzer, Nikitinsky, and van Iterson interested in the soil flora principally from the same standpoint, the isolation of species with a view to the study of the biochemical processes taking place in the soil. Reinitzer and Nikitinsky were primarily interested in the decomposition of humin substances by soil organisms, while van Iterson busied himself only with decomposition of cellulose.

Reinitzer ('00) extracted humin substances from garden, wood, meadow, and heath soils as well as from wood mold. The substances after extraction were never sterilized and were allowed to stand in dishes unprotected from the air. No fungous growth took place. Later these substances were inoculated with a small portion of wood soil containing hyphæ, but with only negative results. While valuable data of a biochemical nature resulted from his work, still as to isolation of soil fungi nothing new can be accredited to him.

Later Nikitinsky ('02) was somewhat more successful in the isolation of soil forms than was Reinitzer. He isolated some thirty forms of bacteria and three species of fungi. While his technic allows considerable room for contaminations, he undoubtedly isolated from the soil the forms mentioned by him, as they have been isolated repeatedly by other investigators since. For his isolation work he used three solutions as follows:

Solution I	Solution II	Solution III
1.5 per cent humic acid	1 per cent humic acid	1.5 per cent humic acid
———	0.5 per cent $(NH_4)_2SO_4$	———
———	———	0.2 per cent cane sugar
0.2 per cent KH_2PO_4	0.2 per cent KH_2PO_4	0.2 per cent KH_2PO_4
0.2 per cent $MgSO_4$	0.2 per cent $MgSO_4$	0.2 per cent $MgSO_4$

These solutions were placed in $1\frac{1}{2}$-liter flasks, plugged, and sterilized in an autoclave at 120° C. for thirty minutes. After cooling they were inoculated with soil extract. The soil extract was obtained from garden soil as well as from the upper and lower layers of forest and humous soils. The humic acid used in the solutions was obtained from the two soils last mentioned.

('85) Hueppe. Die Methoden der Bakterienforschung. Wiesbaden. 1885.
('00) Reinitzer, F. Über die Eignung der Huminsubstanzen zur Ernährung von Pilzen. Bot. Ztg. **58**: 59–73. 1900.
('02) Nikitinsky, J. Über die Zersetzung der Huminsäure durch physikalisch-chemische Agentien und durch Mikroorganismen. Jahrb. Wiss. Bot. **37**: 365–420. *fig. 4.* 1902.

The cultures were allowed to stand ten days. Transfers were then made (exact method not stated) to culture solutions of the same composition as the original. These were again allowed to stand ten days and another transfer made. Finally, a third transfer was made. Ten days after, this third subculture was used for pouring dilution plates after the Koch method. The media used for pouring plates were normal gelatin (10 per cent gelatin, 10 per cent peptone, 0.2 per cent monopotassium phosphate [KH_2PO_4], 0.2 per cent magnesium sulfate [$MgSO_4$], 0.2 per cent glucose), agar (1.5 per cent agar, 1 per cent peptone, 0.2 per cent monopotassium phosphate [KH_2PO_4], 0.2 per cent magnesium sulfate [$MgSO_4$], 0.2 per cent glucose), and sodium humate mixed with gelatin. These pure cultures now obtained were used in Nikitinsky's biochemical studies. In a few instances cultures were obtained by inoculation of gelatin (without humic acid) directly with soil. Further details of this method are not given. The first method yielded mostly bacteria; one yeast is recorded. The second method yielded *Penicillium glaucum*, a Mucor, and a Trichothecium.

Coming now to van Iterson ('04), we find the following method of procedure: Two sterile pieces of Swedish filter paper were placed in glass dishes and these were moistened with tap water (leitungswasser) 100 cc., ammonium nitrate 0.05 gram, monopotassium phosphate 0.05 gram. As inoculation material he used soil or humus, but the best results were obtained when the dishes were left exposed to the air for twelve hours. Following inoculation of the plates they were maintained at 24° C. and the paper was kept moist. He states that after fourteen days to three weeks a rich fungous growth could be noticed. He now obtained pure cultures from these plates for his further study. The exact methods pursued are not given.

The following species were isolated: *Sordaria humicola* Oud., *Pyronema confluens* Tul., *Chaetomium Kunzeanum* Zopf, *Pyrenochaeta humicola* Oud., *Chaetomella horrida* Oud., *Trichocladium asperum* Harz, *Stachybotrys alternans* Oud., *Sporotrichum bombycinum* (Corda) Rabh., *Sporotrichum roseolum* Oud. et Beijer., *Sporotrichum griseolum* Oud., *Botrytis vulgaris* Fr., *Mycogone puccinoides* (Preuss.) Sacc., *Stemphylium macrosporoideum* (Ben. Br.) Sacc., *Cladosporium herbarum* (Pers.) Link, *Epicoccum purpurascens* Ehren. It is unfortunate, from our point of view, that there is no mention made as to just which species were isolated from the soil and which species from the air.

The most extensive work as to the number of species isolated from the soil is that of Oudemans and Koning ('02). The isolation was carried out

('02) Oudemans, C. A. J. A., et Koning, C. J. Prodrome d'une flore mycologique obtenue par la culture sur gélatine préparée de la terre humeuse du Spanderswoud près Bussum. Arch. Néerl. Sci. Nat. ser. 2, 7: 266–298. *pls. 11.* 1902.

('04) van Iterson, C. J. Die Zersetzung von Cellulose durch aërobe Mikroorganismen. Centbl. Bakt. u. Par. Abt. 2, 11: 689–698. *pl. 1.* 1904.

by Koning, while the classification of the species was made by Oudemans. Forty-five species were isolated and classified, and illustrations were made of practically all. All isolations were made from humous soil.

After considerable experimentation Koning found the following to be the best nutrient medium for use in culture work: wort 50 cc., water 50 cc., saccharose 2 per cent, gelatin 10 per cent or agar 1.5 per cent, always allowing the reaction of the medium to remain as it happened in preparation. However, this was always acid.

To begin his cultures, Koning introduced into a platinum capsule, heated to redness for sterilization and then allowed to cool, a fragment of humus, by preference the remains of a leaf of about 1 sq. cm. This humus was taken near the surface. He now poured about 1 cc. of sterilized water into the capsule, and by means of a glass rod (sterilized by flaming) triturated the fragment of humus. The bouillon thus obtained was introduced, with the aid of a platinum loop made to hold nearly 50 mg. of liquid, into a test tube containing 10 cc. of water. This dilution was the most advantageous, as taught by his experience. The contents of the test tube were now poured on the surface of plates poured with the nutrient medium given above. After clarification of the liquid — that is, after deposition of the spores, and so forth — the plates were inclined in order to allow the liquid to flow out. After a period of two days at 24° C., the colonies of molds were seen to develop. From these Koning obtained his pure cultures.

The following species were isolated: *Mortierella humicola* Oud., *M. isabellina* Oud., *M. pusilla* Oud., *M. subtilissima* Oud., *Mucor geophilus* Oud., *Absidia coerulea* Bainier (*Mucor Saccardoi* Oud.), *M. racemosus* Fres., *Pilaira anomala* (Ces.) Schröt., *Chaetomella horrida* Oud., *C. tortilis* Delacroix, *Sphaeronema Fagi* Oud., *Acrostalagmus cinnabarinus* Cda. var. *nana* Oud., *Amblyosporium echinulatum* Oud., *Arthrobotrys superba* Cda. f. *oligospora* Coemans, *Aspergillus calyptratus* Oud., *Aspergillus Koningi* Oud., *Botrytis vulgaris* Fr., *Cephalosporium acremonium* Cda., *C. humicola* Oud., *C. Koningi* Oud., *Monilia acremonium* Delacroix, *M. geophila* Oud., *M. humicola* Oud., *M. Koningi* Oud., *Monosporium silvaticum* Oud., *Naematogonium humicola* Oud., *Penicillium desciscens* Oud., *P. geophilum* Oud., *P. glaucum* Link, *P. humicola* Oud., *P. silvaticum* Oud., *Spicaria decumbens* Oud., *S. elegans* (Cda.) Harz, *S. silvatica* Oud., *S. simplicissima* Oud., *Trichoderma Koningi* Oud., *Alternaria humicola* Oud., *Bispora pusilla* Sacc., *Hormodendrum pallidum* Oud., *Stemphylium botryosum* Wallr., *Torula lucifuga* Oud., *Ciliciopodium Magnusii* Oud., *Graphium Klebahni* Oud., *Stysanus stemonites* (Pers.) Corda, *Stysanus difformis* Oud., *Tilachlidium humicola* Oud.

The brief history already given differs decidedly from that which follows, as a casual comparison will readily show. We note at once, in the consideration of the earlier history, that isolation was concerned with all fungi which might arise. The investigations that are now to be noted are limited to particular groups or species only, depending on whether the work is concerned with saprophytes or with facultative parasites.

Among the first to receive mention should be Butler ('07), to whom much credit is due for his excellent treatise on the genus Pythium. Although he does not deal with soil forms alone, yet his work must constitute a valuable part of the history that we are discussing, because of the species he has unquestionably shown to be soil organisms as well as the new method of isolation evolved by him. We can do no better than use the author's own words in the description of his method:

> Garden earth, preferably from the neighborhood of the roots of higher plants, is taken three to six inches below the surface of the soil and placed in a large shallow vessel to which enough tap water is added to leave a layer free above the earth. In this the substratum is floated. Numerous trials have shown that the nature of the latter is by no means a matter of indifference. . . . By far the best medium which I have found for general use is boiled sliced root of Abutilon, either plain or steeped in decoction of flies. . . . . Working in the tropics I have found it very useful to acidify slightly with citric acid the water used during the first step in the isolation from earth, in order to keep down bacteria. The acid often, however, interferes with spore formation, so that it is necessary to shorten the time as much as possible. After twenty-four hours, the culture substratum is removed and placed in a relatively large quantity of water, and after another twenty-four hours examined.

From a consideration of the above we are again forcibly reminded that there is considerable specialization as to food relations, and so forth, amongst soil organisms, and that different methods and media yield decidedly different results.

The species isolated by Butler are *Pythium de Baryanum* Hesse, *P. intermedium* de Bary, *P. vexans* de Bary, *P. proliferum* de Bary, *P. rostratum* Butler, *P. monospermum* Pringsh.

Following Butler are Hagem, Lendner, and Namyslowski. All three have confined their isolations to the Mucorales and many new species have been found. As a result of the work of the first two, especially, the demand has arisen for a new monograph of the order. This demand is supplied by Lendner's "Les Mucorinées de la Suisse," 1908. But even since that date these investigators have still isolated many new species, so that the monograph is now somewhat incomplete in that about nine new species are not considered within its pages.

('07) Butler, E. J. An Account of the Genus Pythium and Some Chytridiaceae. Mem. Dept. Agr. India, Bot. Ser. No. 5. 1: 1–160. *pl. 10.* 1907.

Hagem ('08, '10) isolated the following eighteen species of Mucorales, nine of which are new to science: *Absidia Orchidis* (Vuill.) Hagem, *A. glauca* Hagem, *A. spinosa* Lendner (syn. *Mucor Norvegicus* Hagem), *Mucor Ramannianus* Möller, *M. hiemalis* Wehm., *M. strictus* Hagem, *M. mucedo* (Linné) Bref., *M. Christianiensis* Hagem, *M. dispersus* Hagem, *M. sylvaticus* Hagem, *M. flavus* Bainier, *M. genevensis* Lendner, *M. racemosus* Fres., *M. griseo-cyanus* Hagem, *M. corticolus* Hagem, *M. plumbeus* Bonord., *M. sphaerosporus* Hagem, *M. saturninus* Hagem. He has also isolated four species of Actinomyces. His work on the species of Actinomyces was instituted primarily in order to study the distribution of animal pathogenic forms. As yet he has not succeeded in connecting any pathogens with those found in his culture work. The paper " Untersuchungen über Norwegische Mucorineen, II" is principally a biochemical study having for its basis the species of Mucor isolated from the soil. Of interest to us in this connection is Chapter I, " Die Verbreitung der Mucorineen im Erdboden," in which a general discussion is given of the distribution of these fungi in various soils. The two other papers deal with descriptions of isolated species and technic. To Hagem must be given foremost rank among the investigators of soil organisms as to morphological as well as biochemical studies.

His soil samples were taken as follows:

> In order to investigate the Mucorale content of a soil sample, it is usually sufficient to sprinkle three to four petri dishes with small amounts of soil. The colonies spread very quickly over the substratum and must be transferred to new substrata again and again as soon as fructification begins. The smaller forms, as *M. Ramannianus* and *Zygorrhynchus Moelleri*, are very easily overgrown by larger forms, as *M. hiemalis*, and it is therefore appropriate to use a great number of plates and to inoculate each plate with a few small particles of soil.

Hagem has investigated, for their Mucorale content, different soils such as arable, meadow, garden, wood, and the like. To this end, either the samples of soil were taken at the locality and placed in sterilized reagent flasks and then brought to the laboratory, where petri dishes containing wort-agar were inoculated; or the dishes were taken to the field, where they were inoculated with small particles of soil transferred by means of sterile forceps.

The method of obtaining pure cultures is worthy of somewhat detailed description, particularly since so much is written concerning heterothallic species exhibiting homothallicism, and vice versa. It is quite possible

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('08) Hagem, Oscar. Untersuchungen über Norwegische Mucorineen **1**: 1–50. *fig. 22.* 1908. (Reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 1907.)

('10) ——— Untersuchungen über Norwegische Mucorineen **2**: 1–152. 1910. (Reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 4, 1910.)

('10) ——— Neue Untersuchungen über Norwegische Mucorineen. Ann. Myc. **8**: 265–279. *figs. 1–8.* 1910.

('10) ——— Einige Beobachtungen über die Verbreitung der Actinomycetes in der Natur. Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 197–205. 1910.

that the results of some workers can be attributed to cultures which are not the descendants from a single spore. The acute observer, and he who has worked with the Mucors to any extent, knows that it is no easy task to pour plates with spores distributed singly. Usually they adhere in twos and threes. Hagem is the first to warn us in print of this condition. His method of obtaining pure cultures from a single spore is based primarily on this fact and is as follows:

> With a platinum needle, some spore material is transferred to a flask containing about 30 cc. of sterile water. After vigorous shaking, one pours a few cubic centimeters of the spore-containing water into a second flask containing water, and again after vigorous shaking a few drops are transferred from the second flask to a third. After repeated shaking of this, 2 cc. are poured on the solid nutrient stratum of a poured petri dish and distributed over the whole surface. The spores are now allowed to settle and thereafter the water is carefully poured from the dish. The dish is now left at room temperature for two to five days, and when the spores have begun to germinate an attempt is made to isolate a colony. To do this, the dish is opened and brought quickly under the microscope (enlargement about 50). At a glance one detects whether the colony has originated from a single spore. Transfer is now made to the substratum of a second dish.

This operation of determining that a colony is the product of a single spore allows some possibility of contamination while the plate is left uncovered and during the observation. The chances of contamination are very slight, however.

The writer employs a method in vogue in the laboratory of the Department of Plant Pathology, Cornell University, which is probably somewhat more commendable than that of Hagem. This method can be used to advantage especially when pouring plates with spores as large as those of most species of Mucor. The method is as follows: Plates are poured so that a very thin layer of the solid nutrient medium covers the bottom of the dish. Inoculation of the plates is made after the Hagem method. After germination of the spores, instead of removing the cover of the dish, the dish is inverted and placed on the stage to make the observation. The glass immediately above the spore (this, of course, while the dish is inverted) is marked with india ink in order to assure no mistake in transfer of the proper colony.

Contemporary with Hagem in Norway, we find Lendner ('08) in Switzerland at work on a study of the Mucorales as to distribution, culture, classification, and so on. His studies have resulted in the admirable monograph already cited. In a study of the habitat of the species of this order, the author considers, in connection with a number of pabula, that of the soil. One species, *Mucor botryoides*, is not listed in the monograph but has been isolated from the soil more recently by Lendner ('10).

('08) Lendner, Alfred. Les Mucorinées de la Suisse. 1–180. *pls. 1–3. fig. 59.* 1908.
('10) ——— Nouvelles Contributions à la Flore Cryptogamique Suisse. Bul. Soc. Bot. Genève ser. 2, 2: 78–81. *figs. 1–4.* 1910.

His method of isolation and the principal media used in the same were as follows:

> The media used for isolation work consisted either of wort-gelatin in tubes or in Erlenmeyer flasks, or of moist bread. The moist bread proved the more advantageous. In preparation of the latter medium the bread was placed in the petri dishes and only sufficient water was added to allow the bread to remain solid after sterilization at 120° C. Before sterilization the dishes were wrapped in blotting paper and were opened only just previous to inoculation. The plates were inoculated with the particular soil (garden and wood soil principally) by means of a flamed match in lieu of the use of a platinum needle. The plates were next carefully wrapped in sterilized paper and preserved in a case for that purpose.

The species isolated by Lendner are: *Absidia Lichtheimi* (Lucet et Costantin) Lendner, *A. spinosa* Lendner, *Mucor adventitius* Oud. var. *aurantiaca* Lendner, *M. genevensis* Lendner, *M. botryoides* Lendner, *M. lamprosporus* Lendner, *M. griseo-cyanus* Hagem, *M. Jansseni* Lendner, *M. dimorphosporus* Lendner.

Namyslowski ('10) needs mention only so far as to state that he has isolated *Zygorrhynchus Vuilleminii* Namy., *Mucor microsporus* Namy., and *Rhizopus arrhizus* Fischer from the soil. In the literature consulted, nothing is stated as to the method of isolation from the soil samples.

In this country Professors Selby and Manns ('09) have devised a method that can be used to advantage in a study of the soil flora, especially when the fungi are in a sporulating stage. While the specific success that has attended this method is not given, still we are led to believe that it has been used to advantage. To quote from the bulletin: "Washings from the soil in which diseased plants occur or washings of samples of seed grain can be placed in the centrifuge (physicians' centrifuge) and there subjected to the rotation and consequent centrifugal effects." In order to be of any value in soil work, it goes without saying that platings must be made from the washings.

Rivas ('10), as the two previous workers, needs mention not because of the fungi he has isolated but because of the method used in collecting his soil samples. It is true that he has isolated ten cultures of molds in connection with thirty cultures of bacteria, but, since no descriptions are given, his work on fungi has no taxonomic value; that is, it does not advance our knowledge of soil forms. His method is given in the following citation:

> The soil was collected in clean test tubes, previously sterilized by dry heat at 200° C. for fifteen minutes or more until a slight browning of the cotton plug took place

('09) Selby, A. D., and Manns, Thos. F. Studies in Diseases of Cereals and Grasses. Ohio Agr. Expt. Sta. Bul. 203: 191. 1909.

('10) Namyslowski, B. Studien über Mucorineen. Bul. Acad. Sci. Cracovie, Class. Math. et Nat. ser. B. June 1910: 477–520. *pl. 19.* 1910.

('10) ——— Zygorrhynchus Vuilleminii une Nouvelle Mucorinée Isolée du Sol et Cultivée. Ann. Myc. 8: 152–155. *fig. 9.* 1910.

('10) Rivas, D. Bacteria and other Fungi in Relation to the Soil. Contrib. Bot. Lab. Univ. Penn. No. 3, 3: 243–274. 1910.

(indication of decomposition of organic matter, hence complete sterilization). In like manner all the glassware (test tubes, pipettes, flasks, etc.) was sterilized.

At the time of collecting the samples, after removing the leaf mould layer, the cotton plug was removed from the test tube which was immediately inserted vertically in the ground with a gentle rotary motion to a depth of about 3 to 5 cm. This test tube was withdrawn and the cotton plug immediately replaced. In this manner the uppermost part of the soil, which contains the greatest number of bacteria, was obtained. In cases where it was desirable to collect the samples from the deeper portions of the soil, a vertical cut was made and, after scraping the surface with a sterilized spatula, the sample was collected as above indicated, except that the test tube was inserted horizontally at the desired depth 10 to 12 cm. below the surface.

For the study of the moulds, the samples were taken from that part of the leaf mould layer next to the soil after the top leaves were carefully removed. The material was collected in sterile test tubes and inoculated on nutrient agar plates by touching and gently rubbing the material on the surface of the medium. The plates were incubated at 37° C. and at room temperature for some days, after which a luxuriant growth was obtained. This collection was made during autumn, when the growth of moulds on the ground was found to be more luxuriant.

Beckwith ('11), in North Dakota, found representatives of the following genera to be present in what he terms "wheat-sick soil". Fusarium, two species; Colletotrichum, two species; Macrosporium, Alternaria, Spicaria, Verticillium, Rhopalomyces, Cephalothecium, and Helminthosporium. It would be highly interesting to know whether the same results would follow provided isolations were made in late summer, autumn, and winter, presuming, however, that the above results followed isolations made in May, June, and July. While some of the above fungi have been found repeatedly in the soil, this is the first report of the isolation of others. Without questioning the results, it seems peculiar, however, that no Penicillia nor Mucors should have been encountered, as species of these two genera have been quite generally isolated from the earliest investigations to the present.

In describing his method of isolation and the kind of media used, citation is made from the original:

> A soil solution was made by mixing one part of soil with ten parts of distilled water. This mixture was agitated frequently for twenty-four hours, in order that such readily soluble matter as was present in the soil might go into solution. This solution was then filtered through Pasteur bougies in order to clarify it, and then, without further treatment, was made into a solid medium by the addition of one and one half per cent of agar-agar. The reaction of this medium was very slightly acid, being .02 per cent normal.
>
> Soil samples were collected from a depth of two inches below the surface, using proper precautions to guard against contamination, and a suspension made by adding one gram of the sample to 10 cc. of sterile distilled water. After two minutes agitation in order to obtain as even a mixture of the soil particles and water as possible, this suspension was plated out on the soil agar. Plates were incubated four days at 29°–30° C. After growth had taken place, the cultures were purified.

We may well close this historical discussion by taking into consideration the second method mentioned in the introduction for the determination

('11) Beckwith, T. D. Root and Culm Infections of Wheat by Soil Fungi in North Dakota. Phytopathology 1: 170–176. 1911.

of the presence of facultative parasites in the soil: that of growing the crop under control experimentation and, provided disease arises, of isolating the organism from the host in case it is of parasitic nature. Saprophytes may likewise be isolated from the debris of plants after death has occurred.

While a number of organisms causing disease in certain crops are generally recognized as living in the soil as saprophytes, at least for some years, still we are rather prone to say such is the case without any too much evidence. It cannot be emphasized too strongly that more work of the nature of Busse, Peters, and Ulrich ('11), connected with the demonstration of the cause of the " Wurzelbrand " of the sugar beet and the presence or absence of the causal organisms in the soil, should be undertaken. A brief discussion of the history of investigations on this subject is as follows: Busse and Ulrich ('08) demonstrated that beet seed-balls were attacked by *Phoma Betae* Fr., while the two other fungi known to produce " Wurzelbrand "— *Pythium de Baryanum* Hesse and *Aphanomyces laevis* de Bary — could not be demonstrated in any case as occurring on the seed-balls. The conclusion of their work is that the diseases produced by the two latter-mentioned fungi do not take their starting point from the seed.

Krüger ('93) came to the conclusion, as a result of his investigations, that infection of beets can come from the soil. Perhaps this is not conclusive, as his communications are too general.

Hiltner and Peters ('05) disinfected the seed-balls after the Hiltner sulfuric acid method (l. c. 220). In all three soils investigated (which were obtained from different sources and were of different natures), the authors found that when sterilized soil, as well as sterilized seed-balls, was used, some disease arose. These results must undoubtedly be attributed to improper sterilization, and, according to the evidence of the following citation, the seed-balls could not have been sterilized.

Busse, Peters, and Ulrich ('11) found that on complete sterilization of soil and seed-balls no " Wurzelbrand " could be produced. When completely sterilized seed-balls but unsterilized soil were used, " Wurzelbrand "

('93) Krüger, F. Phoma Betae Fr. als einer der Erreger von Wurzelbrand der Rübenpflanzen. Zeitsch. Ver. Rübenzuckerind. 43:—. 1893; cited in Arb. Kais. Biol. Anst. Land-. und Forstw. 6: 261. 1908.

('05) Hiltner, L., and Peters, L. Untersuchungen über die Keimlingskrankheiten der Zucker-. und Runkelrüben. Arb. Kais. Biol. Anst. Land-. und Forstw. 5: 207–253. 1905.

('08) Busse, W., and Ulrich, P. Über das Vorkommen von Wurzelbranderregern auf der Rübensaat. Arb. Kais. Biol. Anst. Land-. und Forstw. 6: 373–384. 1908.

('11) Busse, W., Peters, L., and Ulrich, P. Über das Vorkommen von Wurzelbranderregern im Baden. Arb. Kais. Biol. Anst. Land-. und Forstw. 8: 260–302. 1911.

of the nature produced by *Pythium de Baryanum* Hesse and *Aphanomyces laevis* de Bary occurred in soil that contained these organisms. (These organisms are not in all soils, which is to be expected; still they are quite generally distributed in Germany.) With the use of completely sterilized soil and unsterilized seed-balls, "Wurzelbrand" produced by *Phoma Betae* Fr. occurred. The authors conclude that *Phoma Betae* Fr. does not live from season to season in the soil, but that it is carried over on the seed-balls; on the other hand, *Pythium de Baryanum* Hesse and *Aphanomyces laevis* de Bary live as saprophytes in the soil, and under suitable conditions they can attack the beet. In passing it should be stated that the number of soils tested was more than sufficient to warrant the conclusions. Some of the soils had not been in beets since 1899; some since 1902, 1903, and 1904; others had been in beets in 1908, when this work was completed.

That *Phoma Betae* Fr. can be carried over winter in the soil is supported by Frank ('95). From the nature of his investigations and the evidence against his view, we may conclude that his point is not well taken.

From the above data, it must be accepted that *Pythium de Baryanum* Hesse and *Aphanomyces laevis* de Bary constitute a part of the soil flora; and that *Phoma Betae* Fr. has not as yet been proved to live in the soil.

Manns ('11) has worked with *Fusarium oxysporum* Schlecht. (*Fusarium orthoceras* Appel), causing the dry rot of potatoes. The evidence to the effect that this fungus may live in the soil is similar to that just given with respect to *Pythium de Baryanum* Hesse and *Aphanomyces laevis* de Bary.

Finally, it should be stated that there are many plant pathologists who have given rather convincing circumstantial evidence to allow the acceptance that certain facultative parasites, as *Fusarium vasinfectum* Atk., *Pythiacystis citrophthora* R. E. & E. Smith, *Oospora scabies* Thaxter, *Thielavia basicola* (B. & Br.) Zopf, and others, can live as pure saprophytes in the soil for a period of several years. However, space will not allow of a presentation of this evidence.

PRESENT INVESTIGATIONS

Soils examined

The writer's investigations were restricted to a study of the fungi in arable soil. The original plan was to take a soil sample every month of the year from the same field. This plan was later partially abandoned.

('95) Frank, A. B. Neue Untersuchungen über Phoma Betae. Zeitsch. Ver. Rübenzuckerind. D. R. 45: 180 and 272. 1895.

('11) Manns, T. F. The Fusarium Blight and Dry Rot of the Potato. Ohio Agr. Expt. Sta. Bul. 229: 316–317. 1911.

The first three samples, A, B, C, were taken in July, August, and September from an oats field near the Agricultural College at Ithaca. When the first sample was taken, the oats were nearly ripe. When the second was taken, the oats had been harvested. This field was considered worn out in the early seventies; since that time it has grown a crop every year. The rotation practiced has been wheat, corn, and oats; the last-named crop was grown in 1910. The field has received no coating of manure since 1874. The soil is a Dunkirk clay loam.

The sample for D isolation (October) was taken from a barrel of soil shipped from East Hampton, Long Island. The soil was a sandy loam and in 1910 had grown a crop of potatoes. The harvest had been small; probably a conservative estimate would be fifty per cent of the normal. The prevalent diseases were those caused by *Oospora scabies* Thaxter, *Corticium vagum* B. & C. var. *Solani* Burt, and *Fusarium oxysporum* Schlecht. Further history pertaining to this soil was not obtained, except the fact that the field has been under cultivation for many years.

Samples E, F, G, H, and I (November, December, 1910; January, February, and March, 1911) were taken from the plant-breeding experimental garden east of the college. The land has borne crops constantly since the early seventies and probably has been under cultivation for the major part of one hundred years. The soil in that part of the garden where the samples were taken is a Genesee silt loam. The crop grown in 1910 was peppers.

Samples J, K, L, M, N, and O (May to September, 1911) were taken from a potato field near Atlanta, N. Y. The soil is probably a Volusia gravelly sandy loam. The field has been under cultivation constantly for many years. Among the crops grown have been potatoes, clover, and oats. The crop in 1911 was potatoes.

Toward the latter part of the summer, samples were taken both from a part of a field to which sulfur had been applied and from a part that had been left untreated serving as a check in some other experimental work. The purpose of making isolations from these samples was to find out if sulfur, three months after application, had changed in any way the fungous flora of the soil. The results proved to be negative.

Methods of taking soil samples

Samples A, B, C, D, and E were obtained after the same manner. The instrument for taking the samples consisted of an iron tube, one inch in diameter and about eight inches long, threaded at both ends. The threads on the one end served for fastening the tube to a rod (used as a handle similar to that of a soil auger) by a reducing coupling. This end of the tube was plugged with cotton. The threads on the other end served for

receiving a threaded cap that was made to fit very snugly. The tube, being closed by means of the cotton plug and the cap, was sterilized in a hot air sterilizer for one hour at 140° C. The tube was attached to the handle on arriving in the field, and after the very topmost layer of soil (approximately one fourth inch deep) had been removed, the cap was removed and the tube inserted into the soil by a rotary motion. The soil being under cultivation, the tube could be inserted to a depth of about six or seven inches without much difficulty. The tube was now extracted from the soil and the cap again attached. The main objection to taking the sample by this method lies in the resistance offered by the tube to the entrance of the soil. When the tube is inserted into the soil seven inches, the soil to this depth is not sampled owing to compression.

In December, 1910, the soil had become frozen so that samples could not be taken by using the above-mentioned tube. The following method was therefore resorted to during December, January, February, and March: A pit approximately ten inches wide, two feet long, and one foot deep was dug. With a sterile knife (flamed over an alcohol lamp) the soil was removed from the edge of the pit, where it was desired to obtain the samples. After removal of this soil, the knife was again sterilized and the sample was taken at the desired depth, one to three inches, and removed as quickly as possible to a sterile wide-mouthed glass bottle, after removal of the cotton plug. Immediately following the introduction of the soil into the bottle, the cotton plug was again replaced. A second sample was taken directly below the first at a depth of four to five inches, and again a third at a depth of six to eight inches. Precautions were always observed to avoid as much as possible any contamination.

In May, 1911, laboratory equipment as complete as possible was shipped to Atlanta, N. Y., where the summer's field work was to be carried out. Having only a modified Arnold sterilizer at command, the method of taking samples necessarily had to be altered.

Samples J, K, L, M, and N were taken after the following manner: Three Erlenmeyer flasks, each containing 50 cc. of distilled water and carefully plugged with cotton, were sterilized in the modified Arnold sterilizer for thirty minutes at 97° to 99° C. on three consecutive days. After sterilization they were taken into the potato field where the samples were to be collected. A pit was dug similar to that described above in the winter collection of samples. At each of the depths two, four, and six inches, a small quantity of the soil (approximately one fifth gram) was taken on the end of a sterile scalpel (flamed in an alcohol lamp) and introduced into each of the Erlenmeyer flasks. Every precaution was observed to avoid contamination, as previously mentioned. The flasks containing the inoculated water were now taken to the laboratory, where they

were vigorously shaken at intervals during two to four hours in order to break up the soil lumps and liberate any enclosed fungus spores.

Toward the end of the summer of 1911, another method for the isolation of fungi, which can be used apparently to considerable advantage, was perfected. The writer had opportunity to take but one sample to test this method; in this case, however, it yielded very satisfactory results. The method is as follows: A lamp chimney of sufficiently small size to allow the passage of the top through the mouth of a pint or quart fruit jar, when the chimney is inverted, was used as a retainer of the sample. To serve as a support for the soil, four thicknesses of cheesecloth were fastened over the top of the chimney. The base of the chimney was plugged with absorbent cotton. After inversion, the top of the chimney was passed through the mouth of the jar and the chimney placed in position. Absorbent cotton was wrapped about the mouth of the jar and the chimney (Fig. 100). The apparatus was now sterilized. As already stated, fractional sterilization in a modified Arnold was resorted to.

FIG. 100. — *Culture chamber devised for the isolation of soil fungi*

After sterilization the jars were taken into the field and the soil was introduced into the chimneys after the removal of the cotton plugs. When the samples had been thus disposed of, the plugs were again inserted and the apparatus containing the soil removed to the laboratory.

On arriving at the laboratory, the soil in the chimneys was moistened with sterile water, care being taken to use only sufficient water to initiate percolation. The apparatus was now set aside until various fungi could be seen in fruiting condition on the cheesecloth. This was readily observed because of the use of the glass jar. The chimneys were now removed and poured plates were made of the fungi in order to obtain pure cultures. A study was made of the fungi in their fruiting condition on the cheesecloth for comparison with those produced in culture.

Sterilization of glassware

All petri dishes were double-wrapped in manila paper and sterilized for two hours at 140° C. All other glassware, including test tubes, pipettes, bottles, flasks, etc., was sterilized in the hot air sterilizer (except when otherwise stated) for one hour at 140° C.

Preparation and sterilization of media

The media used were soil extract agar, nutrient agar, manure extract agar, potato decoction agar, moist bread, gelatin, Uschinsky's solution, Raulin's culture fluid, Cohn's nutrient solution, lactic acid solution, lactose solution, potato plugs, and wheat stem plugs. The preparation and formula of each follows:

Soil extract agar I.— Prepared according to the following formula:

Distilled water	800 cc.
Soil extract[1]	200 cc.
Dextrose	10 gms.
Dipotassium phosphate (K_2HPO_4)	.5 gm.
Magnesium sulfate ($MgSO_4$)	.2 gm.
Agar	15 gms.

After washing, the agar was always melted over a free flame and stirred constantly in order to prevent burning. It was next added to the above solution and cooked in a double boiler for one hour, then titrated, filtered, and sterilized in the autoclave.

Soil extract agar II.— Prepared according to the formula given under soil extract agar I. The extract was prepared as follows: The soil that served as a basis for this extract was a gravelly sandy loam. It was taken from land seeded to grass and contained many small roots. The moisture content was first determined and was found to be approximately 15.6 per cent. To obtain approximately 3,000 grams of dry soil, 3,555 grams of the wet soil was used. To this soil was added 625 cc. of hydrochloric acid (125 cc. HCl sp. gr. 1.1328, and 500 cc. distilled water). Digestion was allowed to proceed at room temperature for twenty-four hours. The soil was next placed over a warm radiator and allowed to dry for two days. To the soil was then added 1,000 cc. of ammonia water solution (400 cc. ammonia sp. gr. .96, and 600 cc. of distilled water). The soil was allowed to stand at room temperature for twenty-four hours, and then kept over a warm radiator for five days with repeated stirring. No ammoniacal odor could be detected at the end of the period, and the soil felt dry to the touch. Water sufficient to make four liters of filtrate was added. The filtrate constituted the soil extract used during the winter of 1910-1911 and the spring and summer of 1911.

As already stated, this agar was made up identically as was soil extract agar I. It was always titrated and found invariably to be acid. It has been used

[1] The writer is indebted to Dr. H. J. Conn, a graduate student in the Department of Soil Technology, College of Agriculture, Cornell University, at the time this investigation was begun, for the soil extract used as a basis of the agar for isolations A, B, and C, and for suggestions as to making this extract as well as the medium. His work on soil bacteria had led him to conclude that this medium might well be adapted for fungus isolation. While the details of obtaining this extract cannot be given, it does not differ particularly from that described under soil extract agar II.

without any further modifications. Of all the media used, this is superior without question for the isolation of soil fungi and has been the standard medium. While it shows superiority in isolation work, still it seems to produce abnormal growth and for this reason the detailed study of species has been made on other media, nutrient agar and wheat plugs.

Soil extract agar III.— One and one half kilograms of sandy soil were mixed with three liters of water and allowed to stand at room temperature over night (approximately seventeen hours). It was extracted for two hours in the autoclave at 20 pounds pressure. The filtrate obtained was used in the following formula:

Distilled water	800 cc.
Soil extract	200 cc.
Dextrose	10 gms.
Dipotassium phosphate (K_2HPO_4)	.5 gm.
Magnesium sulfate	.2 gm.
Agar	15 gms.

The medium was prepared as were I and II.

Nutrient agar[1].— Prepared according to the following formula:

Distilled water	1,000 cc.
Glucose	5 gms.
Sodium chlorid	5 gms.
Witte's peptone	5 gms.
Liebig's beef extract	3 gms.
Agar	15 gms.

Manure extract agar.— Prepared as follows: To 100 grams of well-rotted horse manure was added 500 cc. of distilled water. This was allowed to stand for twenty-four hours at room temperature and then filtered. The filtrate was used as a stock solution.

I. Distilled water	800 cc.
Manure extract	200 cc.
Agar	16 gms.
II. Distilled water	666 cc.
Manure extract	333 cc.
Agar	16 gms.

[1] This was made by first preparing the bouillon. The calculated amount of water was placed in a double boiler, and beef extract, peptone, sodium chlorid, and glucose were added; this was then cooked for one half hour and at the end the water lost by evaporation was restored. The agar was cut into small pieces, tied loosely in clean cheesecloth, and washed in running tap water for twenty minutes. At the end of this period, the agar was removed from the cloth, placed in a stewpan, and covered with bouillon. It was then boiled over a free flame until all the agar was melted. The melted agar was poured into the bouillon, the whole boiled for one half hour, and then cooled to 58° C.; the well-beaten whites of two eggs were added, and the solution was thoroughly mixed. Cooking in the double boiler was continued for one hour. The water lost by evaporation was restored. Toward the end of the cooking, the solution was titrated to 1.5+. After cooking, it was filtered and sterilized in the autoclave at 17 to 18 pounds pressure for one half hour.

The agar after washing was added to the solution, after being melted over a free flame, cooked for one hour in a double boiler, filtered, and fractionally sterilized. (This medium was used only during a part of the summer of 1911.)

Potato decoction agar.— Prepared as follows: Two average-sized potatoes were washed, pared, and sliced very thin. To these were added about two times their volume of water. This was now heated for two hours, but never allowed to boil. After cooking, it was filtered through cotton, and 30 grams of agar and 5 grams of glucose were added. The mixture was now cooked in the autoclave for twenty minutes at 17 to 18 pounds pressure. After cooking and distribution to test tubes, it was sterilized in the autoclave for thirty minutes at 17 to 18 pounds pressure.

Moist bread.— Prepared by adding only sufficient water to the bread to allow it to remain solid after sterilization in the autoclave.

Gelatin.— Prepared according to Thom ('10). It consisted of 15 per cent gelatin in water; the whole cooked in a double boiler for thirty minutes, then filtered and fractionally sterilized.

Uschinsky's solution.— Prepared according to the formula as given by Smith ('05). Sterilized in autoclave for twenty minutes.

Distilled water	1,000
Glycerin	30 to 40
Sodium chlorid	5 to 7
Calcium chlorid	.1
Magnesium phosphate	.3 to .4
Dipotassium phosphate	2 to 25
Ammonium lactate	6 to 7
Sodium asparaginate	3 to 4

Raulin's culture fluid.— Prepared according to formula as given by Smith ('05).

Distilled water	1,500.
Granulated cane sugar	70.
Tartaric acid	4.
Ammonium nitrate	4.
Ammonium phosphate	.60
Magnesium carbonate	.40
Ammonium sulfate	.25
Zinc sulfate	.07
Ferrous sulfate	.07
Potassium silicate	.07

('05) Smith, E. F. Bacteria in Relation to Plant Diseases. Carnegie Inst. Washington Pub. 27: 197. 1905.

('10) Thom, Charles. Cultural Studies of Species of Penicillium. U. S. Dept. Agr., Bur. Anim. Indus. Bul. 118: 22. 1910.

Cohn's nutrient solution.— Prepared according to formula given by Smith ('05).

Distilled water	1,000.
Acid potassium phosphate (KH_2PO_4)	5.
Magnesium sulfate	5.
Neutral ammonium tartrate	10.
Potassium chlorid	.5

Lactic acid solution.— Prepared according to the following formula:

Water	1,000.
Lactic acid	9.

Lactose solution.— Prepared according to the following formula:

Water	1,000.
Lactose	30.

All the above liquid media were sterilized in the autoclave for fifteen minutes at 17 to 18 pounds pressure.

Potato plugs.— These were cut and prepared as usually recommended in bacteriological work.

Wheat stem plugs.— Stems of mature wheat were cut into pieces approximately three inches long, and three to five were placed in each test tube. Distilled water was now added to cover the lower third of the plugs, and the whole was sterilized in the autoclave for fifteen minutes at 17 to 18 pounds pressure.

Methods of isolation

Isolations were made from samples A, B, D, and E after the following manner: Plates were poured and the media allowed to cool. While the media were cooling, the tube containing the soil sample was washed externally with mercuric chlorid solution (1–1,000). The cap was taken off, and with a sterile scalpel (sterilized in a gas flame) the soil was removed from the tube to a depth of about one fourth inch. This precludes all possibility of using contaminated soil for inoculation of the plates. The smallest masses of soil that could be taken on the point of a sterile scalpel were taken from the tube and planted in the petri dishes containing the agar. Five such masses were placed at different parts of each dish. Before each planting was made, the scalpel was again flamed. In making the inoculation, the covers of the dishes were raised only sufficiently to allow the introduction of the scalpel and immediately thereafter they were replaced in position. Before inoculating a second dish, the soil was

('05) Smith, E. F. Bacteria in Relation to Plant Diseases. Carnegie Inst. Washington Pub. 27: 197. 1905.

removed from the tube again for some distance. This method of procedure was followed until ten dishes had been inoculated, when the soil had been quite generally sampled. After inoculation the dishes were set aside at room temperature and the fungi allowed to develop.

Bacteria usually grow well for a short distance about the planting, but in the course of a few days the fungi very readily outgrow them and transfers to other plates can be made. Pure cultures were often obtained in this way, but for absolute certainty dilution plates were always poured after the fungi had fruited in the transfer plates.

In passing it should be stated that whenever isolations were being made, uncovered plates were usually allowed to stand exposed in the culture room in order to determine the possible contaminations arising in the inoculated plates. A fungus was never accepted as being isolated from the soil unless it showed up repeatedly in the plates of the same isolation.

The tube containing sample C was sterilized externally, as already indicated for the above-mentioned cultures. The soil was transferred from the tube to sterile wide-mouthed bottles by means of a sterile spatula. The soil was mixed as thoroughly as possible by stirring it with a sterile glass rod. Approximately 2 grams was transferred to 100 cc. of sterile water in an Erlenmeyer flask. After a thorough shaking, 1 cc. was transferred to 9 cc. of sterile water contained in a test tube. From these 10 cc. a transfer of 1 cc. was made to 9 cc. of water. The resulting 10 cc. was used for pouring ten plates, 1 cc. to a plate, thus making a dilution of 1–5,000.

The soil of samples F, G, and H was brought to the laboratory and allowed to stand in the bottles over a radiator for four hours. In order to obtain an average of the sample it was now placed in a sterile tin soil sieve, such as is used in soil technology. This instrument makes an ideal apparatus for this purpose, as it is provided with a tin cover and receiver that fit snugly over the top and bottom of the sieve. The only possible contamination arises, therefore, in the transfer of the soil. The sieve was always sterilized by passing it through a flame a number of times just prior to using. In sifting the soil, the lid was occasionally partly removed so that a spatula could be introduced to crush some of the larger particles of soil. Considerable difficulty arose in sifting the soil sample taken from the uppermost part of the soil, because of its wetness.

After sifting had been completed, about one gram (dry weight) of soil was taken from the receiver and weighed out in a tared, wrapped, and sterilized watch glass. The soil was now transferred to 100 cc. of sterile water in an Erlenmeyer flask and thoroughly shaken. As quickly as possible, and during some agitation of the flask, 1 cc. was taken and then transferred to 9 cc. of sterile water in a test tube. This 10 cc. (dilution

1-1,000) was used for pouring ten plates. In other cases further dilution (1-10,000) was made before pouring the plates. Prior to pouring some of the plates, a few drops of potassium hydroxid (KOH) were added to the melted medium in the test tubes to make it alkaline.

As a check on the isolations F, G, and H, isolation I was made. The roots of a pepper and a corn plant left over in the soil from 1910 were carefully removed from the soil and taken immediately to the laboratory, where the soil was washed from them. Roots from each plant were immersed in mercurie chlorid solution (1-1,000), where they were kept for two minutes. Following this, they were transferred to sterile water. Parts of these roots showing discolored areas were transferred with a sterilized scalpel to plates containing agar. The results, in general, were what was expected, that is, the same saprophytes that were isolated from the soil were isolated from the roots. (For details note results of isolations F, G, H, and I.)

Isolations J, K, L, M, and N were made after the same method, which is as follows: From the flasks containing the inoculated water, about 1 cc. of the solution was poured into a petri dish. Into a second and a third dish a few drops of sterile water were poured. By means of a platinum loop, dilutions from plate I were made by transferring a few loopfuls of the inoculated water to the sterile water in plates II and III. To the plates was now added the melted agar cooled to about 40° C. (tested by applying the test tube to the skin just below the eye).

From the soil sample designated O the fungi grew out and fruited on the cheesecloth, as previously mentioned. To isolate these organisms and obtain pure cultures, dilution plates were poured.

Results of isolations

Other forms than those here indicated appeared in the petri dishes. Many forms never fruited; others were lost in pouring dilution plates for pure cultures where some of the rapidly growing fungi crowded out those growing more slowly. A number of apparently different Fusaria were encountered, but classification was not attempted. Three of these Fusaria were used in one series of inoculations of potato tubers; two gave positive results, while one was negative. Time has not permitted further confirmation of these results, so it cannot be stated positively that *Fusarium oxysporum* Schlecht. was isolated from the soil by cultural methods, although the morphology of the Fusaria isolated does not differ materially from the dry rot organism of the potato.

Forms isolated from the different samples.—

A. July 14, 1910. *Chaetomium olivaceum* Cooke & Ellis, Fusaria, *Mucor circinelloides* van Tiegh., *Mucor hiemalis* Wehm., *Mycogone nigra*

(Morgan) emend., *Penicillium expansum* (Link) Thom, *Penicillium chrysogenum* Thom, *Penicillium desciscens* Oud., *Hormodendrum Hordei* Bruhne, *Pleurage verruculosis* n. sp., *Sporormia fasciculata* n. sp., *Sachsia albicans* C. Bay, *Trichoderma lignorum* (Tode) Harz, a pycnidial form that was not determined, red yeast.

B. August 20, 1910. Fusaria, *Hormodendrum cladosporioides* (Fres.) Sacc., *Mycogone nigra* (Morgan), *Penicillium desciscens* Oud., *Penicillium expansum* (Link) Thom, *Pleurage verruculosis* n. sp., Torula not determined, *Trichoderma lignorum* (Tode) Harz.

C. September 9, 1910. *Alternaria fasciculata* Cooke & Ellis, *Aspergillus Koningi* Oud., *Hormodendrum cladosporioides* (Fres.) Sacc., *Penicillium chrysogenum* Thom, *Penicillium expansum* (Link) Thom, *Trichoderma Koningi* Oud., *Trichoderma lignorum* (Tode) Harz.

D. October 8, 1910. *Hormodendrum cladosporioides* (Fres.) Sacc., *Mucor racemosus* Fres., *Penicillium expansum* (Link) Thom, *Trichoderma lignorum* (Tode) Harz, *Zygorrhynchus Vuilleminii* Namy., *Zygorrhynchus Moelleri* Vuill., *Rhizopus nigricans* Ehren.

E. November 17, 1910. *Aspergillus Koningi* Oud., *Aspergillus fumigatus* Fres., Fusaria, *Hormodendrum cladosporioides* (Fres.) Sacc., *Mucor botryoides* Lendner var. *minor* n. var. (isolated also from garden soil), *Mucor hiemalis* Wehm., *Rhizopus nigricans* Ehren. var. *minor* n. var., *Mucor plumbeus* Bonord., *Penicillium expansum* (Link) Thom, *Penicillium terrestre* n. sp., *Spicaria simplicissima* Oud., *Trichoderma lignorum* (Tode) Harz.

F. December 12, 1910. *Alternaria fasciculata* Cooke & Ellis, *Aspergillus fumigatus* Fres., *Aspergillus Koningi* Oud., Fusarium, *Hormodendrum cladosporiodes* (Fres.) Sacc., *Mucor racemosus* Fres., *Mucor circinelloides* van Tiegh., *Mucor hiemalis* Wehm., *Mycogone nigra* (Morgan), *Penicillium humicola* Oud., *Penicillium expansum* (Link) Thom, *Rhizopus nigricans* Ehren., *Rhizopus nigricans* Ehren. var. *minor* n. var., *Trichoderma lignorum* (Tode) Harz.

G. January 7, 1911. *Aspergillus Koningi* Oud., *Trichothecium roseum* Link, *Penicillium expansum* (Link) Thom, *Spicaria simplicissima* Oud., *Trichoderma Koningi* Oud., red yeast.

H. March 10, 1911. *Alternaria fasciculata* Cooke & Ellis, *Acrostalagmus albus* Preuss. var *varius* n. var., Fusarium, *Hormodendrum cladosporioides* (Fres.) Sacc., *Mucor mucedo* (Linné) Bref., *Mucor racemosus* Fres., *Penicillium expansum* (Link) Thom, *Trichoderma Koningi* Oud.

I. March 17, 1911. *Aspergillus globosus* n. sp., *Mucor circinelloides* van Tiegh., *Mucor botryoides* Lendner var. *minor* n. var., *Mucor mucedo* (Linné) Bref., *Mucor racemosus* Fres., *Penicillium expansum* (Link) Thom, *Spicaria simplicissima* Oud., *Thamnidium elegans* Link.

J. May 15, 1911. *Botrytis terrestris* n. sp., Fusarium, *Hormodendrum Hordei* Bruhne, *Mycogone nigra* (Morgan), *Penicillium expansum* (Link) Thom.

K. June 15, 1911. Fusarium, *Penicillium expansum* (Link) Thom, *Penicillium terrestre* n. sp.

L. July 13, 1911. *Hormodendrum cladosporioides* (Fres.) Sacc., *Penicillium expansum* (Link) Thom, *Trichoderma Koningi* Oud., *Zygorrhynchus Vuilleminii* Namy.

M. August 15, 1911. *Aspergillus fumigatus* Fres., *Botrytis terrestris* n. sp., *Hormodendrum cladosporioides* (Fres.) Sacc., *Penicillium expansum* (Link) Thom, *Zygorrhynchus Vuilleminii* Namy.

N. September 8, 1911. *Chaetomium olivaceum* Cooke & Ellis, Fusarium, *Hormodendrum cladosporioides* (Fres.) Sacc., *Hormodendrum Hordei* Bruhne.

O. *Chaetomium olivaceum* Cooke & Ellis, Monilia not determined, *Penicillium expansum* (Link) Thom, *Stachybotrys cylindrospora* n. sp., *Stachybotrys atra* Cda.

Summary of species isolated from all samples.— *Acrostalagmus albus* Preuss. var *varius* n. var., *Alternaria fasciculata* Cooke & Ellis, *Aspergillus fumigatus* Fres., *Aspergillus globosus* n. sp., *Aspergillus Koningi* Oud., *Botrytis terrestris* n. sp., *Chaetomium olivaceum* Cooke & Ellis, *Hormodendrum cladosporioides* (Fres.) Sacc., *Hormodendrum Hordei* Bruhne, *Mucor botryoides* Lendner var. *minor* n. var., *Mucor circinelloides* van Tiegn., *Mucor hiemalis* Wehm., *Mucor mucedo* (Linné) Bref., *Mucor plumbeus* Bonord., *Mucor racemosus* Fres., *Mycogone nigra* (Morgan), *Penicillium chrysogenum* Thom, *Penicillium desciscens* Oud., *Penicillium expansum* (Link) Thom, *Penicillium humicola* Oud., *Penicillium terrestre* n. sp., *Pleurage verruculosis* n. sp., *Rhizopus nigricans* Ehren., *Rhizopus nigricans* Ehren. var. *minor* n. var., *Sachsia albicans* C. Bay, *Spicaria simplicissima* Oud., *Sporormia fasciculata* n. sp., *Stachybotrys atra* Cda., *Stachybotrys cylindrospora* n. sp., *Thamnidium elegans* Link, *Trichoderma Koningi* Oud., *Trichoderma lignorum* (Tode) Harz, *Trichothecium roseum* Link, *Zygorrhynchus Moelleri* Vuill., *Zygorrhynchus Vuilleminii* Namy.

TAXONOMIC CONSIDERATION OF ALL FORMS RECORDED FROM SOIL

In a consideration of the species of soil fungi, it has seemed advisable to classify them under two heads: the facultative parasites and the obligate saprophytes.

While facultative parasites are generally accepted as living in the soil, much of the evidence to support this view is circumstantial. The specific descriptions of the members of this group of organisms have not been given. This has not seemed desirable because of the great amount of valu-

able literature so readily available pertaining to each species, and the difficulty that arises in giving a good tenable description of some species in the space allotted. On the whole it is perhaps preferable to allow the reader to consult the originals, and for this reason the references are inserted.

In a consideration of the obligate saprophytes, it has been the attempt of the writer to make a monograph of all those species that have been thus far isolated from or found growing in the soil. To what extent this has been successful, the future must tell. Probably there are a number of species that have escaped attention. The *nomina nuda* species recorded have been purposely omitted.

The writer purports to present but very little that is new. He has isolated some species that have not heretofore been isolated from the soil but have nevertheless been described. A few species and varieties appear to be new to science. All the figures are original and represent only those species that the writer has isolated.

No key to the determination of all the species has been given because of the little value that it would serve; however, it is hoped that the key to the Mucorales may be of considerable use. This key is practically taken from Lendner's "Les Mucorinées de la Suisse." The only alteration has been in the way of additions to fit the few new species not provided for in that monograph.

Facultative parasites

Olpidium Brassicae Woron. Produces a damping off of cabbage seedlings.

Woronin, Michael. Plasmodiophora Brassicae, Urheber der Kohlpflanzenherni. Pringsh. Jahrb. **11**: 556–561. *pls. 31–32.* 1878.

Olpidium Nicotianae Preiss. At first designated by the author as a new species, now considered by him only a variety of *O. Brassicae.* The parasite, besides attacking tobacco seedlings, is also parasitic on cabbage seedlings, on the roots of *Chenopodium album* and *Portulaca oleracea.*

Preissecker, K. Ein kleiner Beitrag zur Kenntniss des Tabakbaues im Imoskaner Tabakbaugebiet. Tach. Mitt. d. k. k. österr. Tabakregie Heft I, Wien. 1905.

Chrysophlyctis endobiotica Schilb. Produces the wart disease of the potato.

Gussow, H. T. A Serious Potato Disease Occurring in Newfoundland. Dept. Agr., Central Expt. Farm, Ottawa, Canada. Bul. 63. 1909.

Orton, W. A., and Field, Ethel C. Wart Disease of the Potato. U. S. Dept. Agr., Bur. Plant Indus. Circ. 52: 1–11. 1910.

Potter, M. C. A New Potato Disease. Jour. Bd. Agr. Great Britain **9**: 320. 1902.

Schilbersky, K. Ein neuer Schorfparasit der Kartoffelknollen. Ber. Deut. Bot. Gesell. **14**: 36–38. 1896.

Asterocystis radicis De Wild. Attacks flax, producing the so-called "Flacksbrand" in Flanders.

Marchal, E. Recherches Biologiques sur une Chytridinée parasite du Lin. Rev. Myc. **23**: 113–117. 1901.

Urophlyctis leproides (Trabut) Magn. Occurs on root outgrowths of the beet, *Beta vulgaris*.

Magnus, P. On some species of the genus Urophlyctis. Ann. Bot. **11**: 87–96. *pls. 7-8.* 1897.

——— Über eine neue unterirdisch lebende Art der Gattung Urophlyctis. Ber. Deut. Bot. Gesell. **19**: 145–153. *pl. 27.* 1901.

Urophlyctis Rubsaameni Magn. Produces swellings on the roots of *Rumex scutatus* L.

Magnus, P., l. c. 1901.

Urophlyctis Alfalfae (Lagerh.) Magn. Produces swellings on the top and chief side roots of *Medicago sativa* L.

Magnus, P., l. c. 1901.

——— Über die in den knolligen Wurzelauswüchsen der Luzerne lebende Urophlyctis. Ber. Deut. Bot. Gesell. **20**: 291–296. *pl. 15.* 1902.

Aphanomyces laevis de Bary. Causes "Wurzelbrand" of the beet.

de Bary, Anton. Einige neue Saprolegnieen. Pringsh. Jahrb. **2**: 179. *figs. 17–18.* 1860.

Humphrey, J. E. The Saprolegniaceae of the United States, with Notes on other Species. Trans. Amer. Phil. Soc. Philadelphia **17**: 128–129. 1892.

Kasanowsky, V. Aphanomyces laevis de Bary. I. Entwicklung der Sexualorgane und Befruchtung. Ber. Deut. Bot. Gesell. **29**: 210–228. *pl. 1.* 1911.

Peters, L. Über die Erreger des Wurzelbrandes. Arb. Kais. Biol. Anst. Land-. und Forstw. **8**: 239–246. *fig. 10.* 1911.

Pythium de Baryanum Hesse. Causes damping off of a variety of seedlings.

Atkinson, G. F. The Potting Bed Fungus. New York (Cornell) Agr. Expt. Sta. Bul. 94: 234–247. *pl. 1.* 1894.

Butler, E. J. An Account of the Genus Pythium and some Chytridiaceae. Mem. Dept. Agr. India, Bot. Ser. No. 5, **1**: 86–91. 1907.

Hesse, R. Pythium de Baryanum, ein Endophytischer Schmarotzer. Halle. 1874.

Miyake, K. The Fertilization of Pythium de Baryanum. Ann. Bot. **15**: 653–667. *pl. 36.* 1901.

Ward, H. Marshall. Observations on the Genus Pythium (Pringsh.). Quart. Jour. Mic. Sci. **23**: 485–519. *pls. 34–36.* 1883.

Pythiacystis citrophthora R. E. & E. Smith. Causes the brown rot of the lemon.

Smith, R. E., and Smith, Elizabeth. A New Fungus of Economic Importance. Bot. Gaz. **42**: 215–221. *figs. 1–3.* 1906.

Smith, R. E. The Brown Rot of the Lemon. California Agr. Expt. Sta. Bul. 190: 1–70. *figs. 1–29.* 1907.

Sclerotinia libertiana Fuckel. Causes the lettuce drop.

Humphrey, J. E. Diseases of the Cucumber Plant. A Sclerotium Disease. Massachusetts Agr. Expt. Sta. Rpt. **10**: 212–224. *pls. 1–2.* 1892.

Smith, R. E. Botrytis and Sclerotinia: Their Relation to Certain Plant Diseases and to Each Other. Bot. Gaz. **29**: 369–407. *pls. 25–27. figs. 1–3.* 1900.

Stevens, F. L. A Serious Lettuce Disease. North Carolina Agr. Expt. Sta. Bul. 217: 1–21. 1911.

——— A Serious Lettuce Disease and Method of Control. North Carolina Agr. Expt. Sta. Tech. Bul. 8: 85–145. *figs. 1–31.* 1911.

Stone, G. E., and Smith, R. E. "Drop" of Lettuce. Massachusetts (Hatch) Agr. Expt. Sta. Rpt. **9**: 79–81. 1897. (Compare also **10**: 55–58. 1898; and **11**: 149–151. 1899.)

Corticium vagum B. & C. var. *Solani* Burt. A root and stem rot fungus attacking potatoes, beans, cotton, etc.

Appel, O., and Wollenweber, H. W. Grundlagen einer Monographie der Gattung Fusarium (Link). Arb. Kais. Biol. Anst. Land-. und Forstw. **8**: 141–156. *pl. 1, figs. 60–64; pl. 3, fig. 2.* 1910.

Atkinson, Geo. F. Some Diseases of Cotton. Alabama Agr. Expt. Sta. Bul. 41: 30–39. 1892.

Clinton, G. P. Rhizoctonia (Rosette). Connecticut Agr. Expt. Sta. Rpt. **28**: 325–326. *pl. 26, figs. a-c.* 1904.

Duggar, B. M., and Stewart, F. C. The Sterile Fungus Rhizoctonia. New York (Cornell) Agr. Expt. Sta. Bul. 186: 50–76. *figs. 15–23.* 1901. Ibid. New York (Geneva) Agr. Expt. Sta. Bul. 186: 4–30. *figs. 15–23.* 1901.

Pammel, L. H. Preliminary Notes on a Root-Rot Disease of Sugar Beets. Iowa Agr. Expt. Sta. Bul. 15: 243–251. *pls. 3–4.* 1891.

Rolfs, F. M. Potato Failures (Two Reports). Colorado Agr. Expt. Sta. Bul. 70: 1–20. 1902. Bul. 91: 1–33. 1904.

Rhizoctonia Medicaginis DC. Produces root disease of alfalfa.

De Candolle, A. P. Mémoire sur les Rhizoctones nouveau genre de Champignons qui attaquent les Racines des Plantes, et en particulier celle de la Luzerne cultivée. Mém. Muséum Paris **2**: 209. 1815.

Duggar, B. M. *Rhizoctonia Medicaginis* DC. Fungous Diseases of Plants, 477–479. *fig. 239.* 1909.

Frank, A. B. Krankheiten der Pflanzen **2**: 514–518. 1896.

Heald, F. D. *Rhizoctonia Medicaginis* in America. Phytopathology **1**: 105. 1911.

Kuhn, J. Die Krankheiten der Kulturgewächse, 245. 1858.

Sorauer, P. Handbuch der Pflanzenkrankheiten, 3 ed. **2**: 471. 1908.

Ozonium omnivorum Shear. Produces the root rot of cotton and alfalfa.

Pammel, L. H. Cotton Root-Rot. Texas Agr. Expt. Sta. Rpt. **2**: 61–86. 1889. (Also published as Bul. 7: 1–30. 1889.)

Atkinson, Geo. F. Method of Obtaining Pure Cultures of Pammel's Fungus of Texas Root-Rot of Cotton. Bot. Gaz. **18**: 16–19. 1893.

Shear, C. L., and Miles, G. F. The Control of Texas Root Rot of Cotton. U. S. Dept. Agr., Bur. Plant Indus. Bul. 102: 39–42. 1907.

Oospora scabies Thaxter. Produces scab of potatoes and beets.

Sturgis, W. C. On the Susceptibility of Various Root Crops to Potato Scab, etc. Connecticut Agr. Expt. Sta. Rpt. **20**: 263–266. 1896.

Thaxter, Roland. The Potato Scab. Connecticut Agr. Expt. Sta. Rpt. **1891**: 153–160.

Bolley, H. L. Potato Scab, Nature and Treatment. North Dakota Agr. Expt. Sta. Bul. 4: 1–17. 1891.

Fusarium Lini Bolley. Produces wilt of flax.

Bolley, H. L. Flax Wilt and Flax Sick Soil. North Dakota Agr. Expt. Sta. Bul. 50: 27–60. 1901.

Fusarium oxysporum Schlecht. Causes dry rot of potatoes.

Appel, O., and Wollenweber, H. W. Grundlagen einer Monographie der Gattung Fusarium (Link). Arb. Kais. Biol. Anst. Land-. und Forstw. **8**: 141–156. 1910.

The authors propose the new name *F. orthoceras* for the organism known in the United States as *F. oxysporum* Schlecht. The reasons for this are given.

Manns, T. F. The Fusarium Blight and Dry Rot of the Potato. Ohio Agr. Expt. Sta. Bul. 229: 299–336. 1911.

Smith, E. F., and Swingle, D. B. The Dry Rot of the Potato due to Fusarium oxysporum. U. S. Dept. Agr., Bur. Plant Indus. Bul. 55: 1–64. *pls. 1–8.* 1904.

Fusarium sp. Produces carnation stem wilt.

Atkinson, Geo. F. Carnation Diseases. Amer. Florist **8**: 720–728. 1893.

Sturgis, W. C. Preliminary Investigations on a Disease of Carnation. Connecticut Agr. Expt. Sta. Rpt. **21**: 175–181. 1897.

Fusarium vasinfectum Atk.

Atkinson, Geo. F. Some Diseases of Cotton. III. Frenching. Alabama Agr. Expt. Sta. Bul. 41: 19–29. 1892.

Butler, E. J. The Wilt Diseases of Pigeon-Pea and the Parasitism of Neocosmospora vasinfecta Smith. Mem. Dept. Agr. India, Bot. Ser. No. 9, 2: 1–64. *pls. 1-6.* 1910.

Higgins, B. B. Is Neocosmospora vasinfecta (Atk.) Smith the Perithecial Stage of the Fusarium which Causes Cowpea Wilt? North Carolina Agr. Expt. Sta. Rpt. 32: 100–116. *figs. 1-16.* 1909.

Orton, W. A. The Wilt Disease of Cotton and its Control. U. S. Dept. Agr., Div. Veg. Physiol. and Path. Bul. 27: 1–16. *pls. 1-14.* 1900.

——— The Wilt Disease of the Cowpea and its Control. U. S. Dept. Agr., Bur. Plant Indus. Bul. 17: 1–20. *pls. 1–4.* 1902.

Smith, E. F. Wilt Disease of Cotton, Watermelon, and Cowpea. U. S. Dept. Agr., Div. Veg. Physiol. and Path. Bul. 17: 1–53. *pls. 1–10.* 1899.

Fusarium sp.

Essary, S. H. Notes on Tomato Diseases with Results of Selection for Resistance. Tennessee Agr. Expt. Sta. Bul. 95: 1–12. 1912.

Rhizopus nigricans Ehren. Cause of soft rot of the sweet potato.

Halsted, B. D. The Sweet Potato Rot. New Jersey Agr. Expt. Sta. Rpt. 10: 236–237. 1889.

——— Some Fungous Diseases of the Sweet Potato. New Jersey Agr. Expt. Sta. Bul. 76: 4–7. *figs. 1–2.* 1890.

——— Experiments with Soil Rot of Sweet Potatoes. New Jersey Agr. Expt. Sta. Ann. Rpt. 12: 345–354. 1899.

This fungus is technically described and classified with the obligate saprophytes. This is due to the fact that it has frequently been isolated from the soil, and it is deemed advisable to consider it along with the other members of this group.

Thielavia basicola (B. & Br.) Zopf. Produces the root rot of tobacco, legumes, and many other plants.

Briggs, Lyman J. The Field Treatment of Tobacco Root Rot. U. S. Dept. Agr., Bur. Plant Indus. Circ. 7: 1–8. 1908.

Clinton, G. P. Root Rot of Tobacco, *Thielavia basicola* (B. & Br.) Zopf. Connecticut Agr. Expt. Sta. Rpt. 30: 342–368. *pls. 29–32.* 1906.

Gilbert, W. W. The Root Rot of Tobacco Caused by *Thielavia basicola.* U. S. Dept. Agr., Bur. Plant Indus. Bul. 158: 1–55. *pls. 1–5.* 1909. Bibliography appended.

Zopf, W. Uber die Wurzelbräune der Lupinen eine neue Pilzkrankheit. Zeitsch. Pflanzenkrank. 1: 72–76. *figs. 1–2.* 1891.

Trichoderma Koningi Oud. Causes a disease of the sweet potato.

Cook, Mel T., and Taubenhaus, J. J. *Trichoderma Koningi* the Cause of a Disease of Sweet Potatoes. Phytopathology 1: 184–189. *pls. 27-28.* 1911.

Obligate saprophytes

Species of Phycomycetes

Mucorales

Reproduction asexually by spores contained in sporangia. . *Sporangiophorae*
Reproduction asexually by conidia produced either solitary or in chains. . . . . *Conidiophorae*

Suborder Sporangiophorae

I. Sporangia generally only of one kind, spherical or pyriform, with a membrane that dissolves or fractures easily. Sporangioles with persistent membranes occur very rarely and in such cases are disposed without order along the principal sporangiophore. The septum separating the sporangiophore from the sporangium arches in the interior of the latter to form a columella. Zygospores naked or surrounded by appendages . . . . . *Mucoraceae*
II. Sporangia as with the Mucoraceae but of two kinds: the one multispored, with membrane that dissolves, leaving only a naked columella; the other (sporangioles) few-spored, with persistent membrane, often without columella, caducous. The sporangioles are disposed at the extremity of branched sporangiophores, which are fixed at regular intervals on the principal sporangiophore. . . . . *Thamnidiaceae*
III. Sporangia of one kind only, multispored, with membrane for the major part solid, persistent, of a very dark blackish color, or swelling only toward the base. Sometimes the sporangium dissolves, leaving the columella, while at other times it is thrown off at the same time as the columella and opens only after swelling of the membrane. . . . *Pilobolaceae*
IV. Sporangia without a columella, with diffluent evanescent membrane. Zygospores contained singly in a completely closed carposporium. . . . . *Mortierellaceae*

Family Mucoraceae

1. Sporangia pyriform. . . . . *Absidia*
Sporangiag lobose. 2
2. Sporangiophores fasciculate on a rhizoidiferous stolon, located on the nodes opposite the rhizoids; spores often striated longitudinally. . . . . *Rhizopus*
Sporangiophores emerging solitary from the mycelium, no rhizoidiferous stolons; spores generally smooth without longitudinal striations. 3
3. Heterothallic, occasionally homothallic, but in this case the zygophores generally arise from comparatively distant parts of the mycelium, never formed between branches of a single aerial hypha, usually equal. . *Mucor*

Homothallic; zygophores arise comparatively close together, almost invariably originating from a single aerial hypha, usually unequal ..... *Zygorrhynchus*

Absidia

Absidia Orchidis (Vuill.) Hagem, Untersuch. ü. Norw. Mucorineen **1**: 40–43. *figs. 16–18.* 1908; reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 1907. Lendner, Les Mucorinées de la Suisse, 138–140. *fig. 50.* 1908.

Syn. *Tieghemella Orchidis* Vuill., Bul. Soc. Myc. France **19**: 119-126. 1903.

This fungus varies somewhat with the substratum; stolons of different sizes, depending on the concentration of the medium; on rich substratum very strongly and richly branched; on poorer, forming shorter and only solitary new stolons; sporangiophores mostly two together, occasionally 3–4–5, always with a septum 10–20μ below the sporangium; sporangia 35–60μ high and broad (without consideration of apophysis); columella hemispherical to conical, seated on the apophysis, without the apophysis measuring 20–40μ high and broad, or occasionally 5μ broader than high; spores globose, 2.5–3.5μ diameter, in mass weak yellow or with a trace of brown.

Heterothallic; zygospores globose (80–)100–120(–150)μ in diameter; exospore with warty, starlike thickenings; suspensors formed by the stolons, with a circle of 10–14 one-celled, frequently brown appendages that interweave with those of the opposite side and surround the zygospore.

Hab. Isolated frequently from forest and meadow, and garden soil near Christiania, Norway, Hagem.

Absidia glauca Hagem, Untersuch. ü. Norw. Mucorineen **1**: 43–45. *figs. 19–20.* 1908; reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 1907. Lendner, Les Mucorinées de la Suisse, 136–138. *figs. 48–49.* 1908.

Colonies at first white, soon, however, more or less bluish green; stolons of the first order very low and slightly bent, up to several centimeters long, up to 25–30μ thick, ending for the major part with few rhizoids, producing short (1–)2(–3) new stolons, blue-green, those of the last orders frequently strongly bent; sporangiophores straight, erect, mostly two together, occasionally also several, 100–600μ high, 5–10μ thick, frequently producing one or two side branches, which are again branched. Also occasionally instead of a branch a new stolon is formed, always with a septum close to the sporangium; sporangium together with the apophysis pyriform, with easily dissolving wall; columella hemispherical, mostly without but occasionally also with a short, thick process, without apophysis 20–30μ high by 25–35μ broad; spores very small, globose, 2.5–3.5μ in diameter, in mass yellowish.

Heterothallic; zygospores globose, very variable in size, mostly about 100μ in diameter, opaque, black; exospore with large, plate-like, opaque thickenings; suspensors formed from the stolons, with a circle of 10–18 one-celled, green appendages that interweave with those of the opposite side and more or less surround the zygospore.

Hab. In light humous soil near Christiania, Norway, Hagem; Switzerland, Lendner.

Absidia Lichtheimi (Lucet et Costantin) Lendner, Les Mucorinées de la Suisse, 143–144. *fig. 52.* 1908.

Syn. *Mucor Lichtheimi* Lucet et Costantin, Arch. Par. **4**: 380. 1901.
Lichtheimia corymbifera Vuill., Bul. Soc. Myc. France, fas. 2, **19**: 119-126. 1903.
Mucor corymbifer Cohn. Lichtheim, Zeitsch. Klin. Med. **7**: 174. 1884.

Sporangiophores creeping, forming a white floccose felt, terminated by a corymb of branches that are more or less elongated and carry sporangia; shortly beneath this corymb, the branches are disposed in groups. These branches carry much smaller sporangia. Sporangia erect, hyaline, pyriform, with an infundibuliform apophysis that gradually passes into the stalk of the sporangiophore, with mean diameter 45-60μ, maximum 70μ, minimum 10–20μ; membrane of sporangium smooth, hyaline, transparent, diffluent, leaving a basal collarette; columella large, hemispherical or globose, 10–20μ, smooth (or supplied with short spines), gray, fuliginous, or brown-black. The apophysis and the pedicel have also the same tint. Spores are globose, subglobose, or more rarely oval, hyaline, small, for the major part 2 by 3μ (some larger, 4 by 6.5μ). Zygospores unknown.

Hab. Pathogen in canines. Isolated from soil, Geneva, Switzerland, Lendner.

Absidia caerulea Bainier, Bul. Soc. Bot. France, **36**: 184-186. 1889. Lendner, Les Mucorinées de la Suisse, 141. 1908.

Syn. *Pro-Absidia Saccardoi* Vuill., Bul. Soc. Myc. France, fas. 2, **19**: 119-126. 1903.
Mucor Saccardoi Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 278. 1902.

Vegetative hyphæ blue-violet, continuous, branching, unequal, sometimes nodular; sporangiophores solitary, borne directly on the mycelium, attaining 25 mm. in length, terminated by an infundibuliform apophysis, with septum 12–24μ from summit; sporangia uniform, globose, 36–42μ, passing from pale violet to grayish black and then to brown; membrane of sporangium smooth, diffluent, leaving a basal collarette; columella hemispherical or obconical, often surmounted by a nipple; spores numerous, small, smooth, pale violet, globose, 4–7μ; zygospores 60μ in diameter, brown, globose, rugose-verruecose; suspensors straight, widening into a funnel, provided with 10–20 long, slender (7μ thick) circinate appendages disposed in a single verticil; azygospores equal; chlamydospores smooth, intercalary.

Hab. Humous soil from wood near Bussum, Holland, Koning.

Absidia spinosa Lendner, Bul. Herb. Boissier ser. 2, 5: —. 1905; Les Mucorinées de la Suisse, 132–134. *fig. 46.* 1908.

Syn. *Absidia cylindrospora* Hagem, Untersuch. ü. Norw. Mucorineen 1: 45–46. *fig. 21.* 1908; reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 1907.

Culture forming very dense, grayish, cotton-like aerial mycelium which attains a height of 2.5 cm.; stolons slightly incurved; curves carrying sporangiophores in fascicles of 2 to 3; sporangia pyriform, measuring 34μ long without the apophysis and 28μ thick; columella 20μ thick, vase-like in form, terminated by a blunt or round point, attaining one third of the length of the columella. A septum situated 25μ below the apophysis separates the sporangia from sporangiophores; spores hyaline, oval or short cylindrical, 2 by 4–5μ.

Zygospores globose or duliform, verrucose, formed by the fusion of two unequal gametes supported by a bifurcated filament. The most vigorous suspensor alone produces prolongations or circinate appendages.

Hab. Isolated from garden soil, Geneva, Lendner; from humous soil near Christiania, Norway, Hagem.

Rhizopus

Rhizopus nigricans Ehrenberg, *Mucor Stolonifer* in Sylv. Myc. Berol., 25. 1818; *Rhizopus nigricans* in Nova Acta Acad. Leop. 11: 198. 1820.

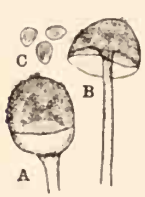

FIG. 101.—*Rhizopus nigricans* Ehren. A, *columella with adhering spores and apophysis, x 60;* B, *columella after becoming pileate, x 60;* C, *spores, x 236.6*

Stolons far-spreading, even growing onto and spreading over the culture glass, covering the substratum and its neighborhood with thick cobwebby growths 1–3 cm. long and occasionally still longer, simple or sparsely branched, occasionally fork-like internodes, with smooth, at first hyaline then finally brown, membrane, contents colorless; rhizoids more or less richly branched, at first with colorless, later with brown or black-brown, smooth, thick membrane, as thick as 16μ at base and 5μ at tip, finally uniseptate; sporangiophores seldom single, mostly in clusters of 3–5 occasionally up to 10, unbranched, 0.5–4 mm. high, 24–42μ thick, with smooth, finally brown or black-brown, membrane, contents colorless, with apophysis of sporangium more or less hemispherical, large, 100–350μ broad, at first snow-white then becoming at maturity black, erect; columella with broad base, very large, broadly half globose, highly arched, with apophysis 70μ broad by 90μ high to 250μ broad by 320μ high, with brown smooth membrane, often covered with spores after opening of sporangia, often becoming pileate; spores irregularly globose or broad oval, mostly with one or two blunt corners, variable in size

6–17μ in diameter, mostly somewhat longer than broad, with thick double membrane on which are seen meridian-like folds, light pale gray, contents colorless; zygospores globose or barrel-shaped, 160–220μ in diameter; exospore firm, brown-black, opaque, closely beset with half-globose high warts; endospore colorless, thick, with small outgrowths filling the warts of the exospore; suspensors swollen, commonly unequal, almost as broad as the zygospore; azygospore observed.

Isolated from soil, Norway, Hagem; Germany, Adametz; isolated repeatedly by writer from plant-breeding plats near Cornell University during winter 1910–1911. Plant pathology herbarium No. 5,895.

Rhizopus nigricans var. **minor** n. var.

Differs from type in the following particulars: Sporangiophores never attain a height of more than 2.5 mm. and a maximum thickness of 28μ (type 4 mm. maximum height by 42μ maximum thickness). The clusters of sporangiophores vary from 1 to 5, never more (type 1–5, sometimes 10). Spores are more uniform in size and constantly smaller, 4.5–10 by 4.2–6.6μ, and of a dark fuliginous color.

Hab. Soil taken from plant-breeding plats, Cornell University, Ithaca, N. Y., fall 1910.

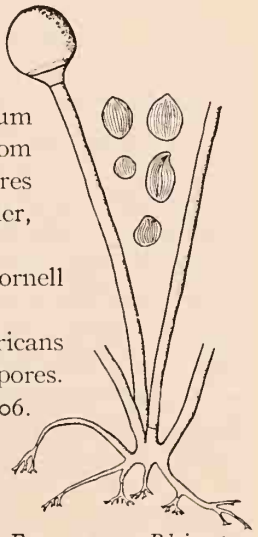

FIG. 102.—*Rhizopus nigricnas Ehren. var. minor. Showing sporangiophores, rhizoids, and columella, x 60; spores, x 533.3*

Rhizopus nodosus Namyslowski, Rhizopus nigricans et les conditions de la formation de ses zygospores. Bul. Intern. Acad. Sci. Cracovie No. 7. 1906. Lendner, Les Mucorinées de la Suisse, 122–123. *fig. 45.* 1908.

Syn. *Mucor Norvegicus* Hagem, Untersuch. ü. Norw. Mucorineen 1: 39-40. *fig. 15.* 1908; reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7. 1907.

Mucor nodosus (Namy.) Hagem, Neue Untersuch. ü. Norw. Mucorineen. Ann. Myc. 8: 280. 1910.

Mycelium at first cottony white, then finally becoming tinted with ocher-yellow. In the midst of the mycelium and on the stolons are found stalks terminated by sporangia; stalks simple or branched, the branches terminated by sporangia, often swollen at some one point, 1–2 mm. high, 12–18μ thick, with smooth, thick membrane that is hyaline at first, then finally becoming pale ocher-yellow or brown.

When the swellings are at the extremity of the stalk, they give rise to a group of 3–5 sporangiophores terminated by sporangia, sporangiophores 1–2 mm. high; sporangia round, 100–200μ in diameter, average 130μ; spores 6–9 by 4–6μ, with longitudinal stripes, giving rise, if they are sown on saccharose, to filamentous mycelium producing chlamydospores 16–34μ

in diameter. Zygospores measure 120–140μ with maximum 180μ, variable in form, being round, oval, or without any particular form. Suspensors equal or different in form and in size. (Description after Lendner.)

Hab. Glacial sediment, altitude 3,000 m., Switzerland, Lendner; tilled soil, Christiania, Norway, Hagem.

Hagem considers his *M. nodosus* and Namyslowski's *R. nodosus* as synonymous, while his *M. Norvegicus* is claimed to be a new species. On the other hand, Lendner considers all three species as identical. The cultures have not been studied by the writer.

Rhizopus arrhizus Fischer, Rab. Krypt. Flora Abt. 4, 1: 233–234. 1892. Hagem, Untersuch. u. Norw. Mucorineen 1: 37–38. *fig. 14.* 1907. Lendner, Les Mucorinées de la Suisse, 121–122. *fig. 44.* 1908.

Differs from *R. nigricans* in being brighter-colored and not spreading so far over the substratum, also in the stolons being less distinct and less differentiated from the sporangiophores; stolons without distinct formation of nodes, with colorless or bright brown membrane; rhizoids pale, developed at the nodes together with the sporangiophores or alone at indeterminate places; sporangiophores ascending or trailing, seldom arising from the stolons singly but mostly 2–10 in umbels or corymbs, 0.5–2 mm. long, simple or once or twice forked, ending in sporangia; sporangia globose, large, 120–250μ in diameter, at first snow-white then finally becoming at maturity black; columella spherical, flattened on the apophysis, 40–75μ high by 60–100μ thick, with brown, smooth membrane; spores globose or oval, one- or two-angled, with longitudinally striated membrane, 4.8–7μ long by 4.8–5.6μ thick, smoky gray. (Description after Fischer.)

Hab. Isolated from soil, Hungary, Namyslowski.

Mucor

I. Sporangiophores unbranched ..... *Mono-mucor*
II. Sporangiophores branched
  1. Branching rare or more frequent, and in this latter case indefinite, in clusters or in corymbs ..... *Racemo-mucor*
  2. Branching definite, in sympodia ..... *Cymo-mucor*

Mono-mucor

Sporangiophores not branched (exception, when the nutrition is unfavorable, branching occurs; this, however, is anomalous).

1. Sporangiophores not exceeding 2 centimeters in length 2
   Sporangiophores more than 2 centimeters long 3
2. Sporangia red, 20-35μ, with diffluent membrane, spores 2.5 by 2μ ..... *M. Ramannianus* Möller

Sporangia green-black, 50–80μ usually 60μ, with diffluent membrane, spores 4–10 by 2.5–5μ ..... *M. hiemalis* Wehmer
Sporangia brownish, 30–80μ mostly 60μ, with nondiffluent membrane, spores 2–3 by 1.5μ ..... *M. microsporus* Namyslowski
Sporangia gray, 80–95μ, with diffluent membrane, spores 8.5 by 4.5μ *M. adventitius* Oudemans

3. Sporangiophores 1–4 centimeters long, spores mostly cylindrical, 5–7 by 2.5–3.5μ ..... *M. strictus* Hagem
Sporangiophores 2–15 centimeters long, spores 6–12 by 3–6μ *M. mucedo* (Linné) Brefeld

Racemo-mucor

Branching indefinite, in groups or clusters or in corymbs.

1. Sporangiophores at first erect, but soon falling 2
Sporangiophores always erect 3
2. Branches of the sporangiophores ascending; sporangia 40–60μ, bright yellow, breaking, leaving a basal collar ... *M. Christianiensis* Hagem
Branches of the sporangiophores mostly reflexed; sporangia 15–45μ, falling closed and remaining intact for a long time *M. dispersus* Hagem
3. Spores very unequal (mixture of numerous small spores with others twice as large), oval or subcylindrical, 4 by 2μ or 5 by 3μ to maximum 8 by 6μ ..... *M. sylvaticus* Hagem
Spores reasonably equal 4
4. Membrane of the sporangium nondiffluent ..... *M. racemosus* Fresenius
Membrane of the sporangium diffluent 5
5. Species very large, 6–8 centimeters high (always over 2 centimeters); spores 9–12 by 4.2μ ..... *M. flavus* Bainier
Species much smaller, never exceeding 2 centimeters high; spores 5–7 by 2.5–3.5μ ..... *M. genevensis* Lendner

Cymo-mucor

Sporangiophores branched in sympodial cymes.

1. Sporangiophores nonerect, incurved, forming a cobwebby network, 1.5 centimeters high, ending in a large sporangium and producing at a short distance below more or less closely clustered branches; secondary branches sometimes dichotomous 2
Sporangiophores circinate 3
Sporangiophores straight, not circinate 6
2. Spores average 8μ ..... *M. botryoides* Lendner
Spores average 6μ ..... *M. botryoides* var. *minor*
3. Sporangiophores never much surpassing 1 centimeter; spores oval, 6μ being maximum length 4

Sporangiophores 0.5–2 centimeters long, the longer noncircinate, the shorter much branched and circinate, sporangia average 60μ, spores average 10μ ..... *M. lamprosporus* Lendner

4. Membrane of the sporangium brown; sporangia often subsessile, spores oval or broad elliptical, 3–4 by 5–6μ.. *M. circinelloides* van Tieghem
Sporangia supported by very long pedicels, often circinate 5
5. Sporangia 60–80μ in diameter, spores 4–6 by 4μ. *M. griseo-cyanus* Hagem
Sporangia 50–60μ in diameter, spores 5–7 by 3.5–5μ
M. corticolus Hagem
6. Spores globose 7
Spores oval 10
7. Species grows poorly on wort-gelatin, forms on bread a short aerial growth of 2–3 mm. high, sporangia 50–70μ in diameter, spores globose, 5–6μ ..... *M. Jansseni* Lendner
Species grows well on wort-gelatin and forms an aerial growth 1–3 centimeters high 8
8. Columella spinescent ..... *M. plumbeus* Bonorden
Columella smooth 9
9. Sporangia 70–110μ in diameter, sporangioles not caducous, spores globose, brilliant, 10μ ..... *M. sphaerosporus* Hagem
Sporangia never exceeding 80 to 90μ, spores 10μ, sporangioles circinate, caducous, sporangiophores more elevated than with *M. sphaerosporus*
M. lamprosporus Lendner
Sporangia 60–80μ, spores normally 8–10μ, spherical or accompanied by abnormal oval spores 8–10 by 30μ, no sporangioles
M. dimorphosporus Lendner
10. Sporangia 50–350μ, columella globose, spores globose or ellipsoidal or angular, 4.2–6.5μ, chlamydospores ..... *M. geophilus* Oudemans
Sporangia variable, lead-gray, those of the shorter sporangiophores 45–180μ, columella oval or ovate, spores broad ellipsoidal, 4.5–10 by 3.5–7μ usually 6.8 by 4.6μ ..... *M. saturninus* Hagem

Mono-mucor

Mucor Ramannianus Möller, Untersuch. ü. ein- und zweijahr. Kiefern im märk Landboden. Zeitsch. Forst- u. Jagdw. **25**: 330. 1903. Hagem, Untersuch. ü. Norw. Mucorineen **1**: 20–21. *fig. 2.* 1908; reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 1907. Lendner, Les Mucorinées de la Suisse, 62–63. *fig. 21.* 1908.

Colonies bright rose-red, very slow-growing; sporangiophores low, 0.5–1 mm. high, either not at all or only slightly branched at the base, 1–3 septate with upper septum 15–20μ below the sporangium; sporangia red, with yellow spore mass visible through the membrane, 20–35μ in diameter;

sporangial wall readily dissolving; columella small, occasionally appearing as a hardly distinguishable swelling, globose or ellipsoidal, 6–12μ high by 6–12μ wide, average 8 by 10–11μ; spores very small, 2.5 by 2μ; zygospores not observed.

Hab. Isolated from forest soil near Christiania, Norway, Hagem.

Mucor hiemalis Wehmer, Der Mucor der Hanfrötte, *M. hiemalis* nov. spec. Ann. Myc. **1**: 37–41. *figs. 1–9.* 1903. Hagem, Untersuch. ü. Norw. Mucorineen **1**: 24–28. *figs. 5–8.* 1908; reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 1907. Lendner, Les Mucorinées de la Suisse, 65–68. *fig. 22.* 1908.

FIG. 103.—*Mucor hiemalis Wehm. Showing columellæ with basal collar, and spores, x 236.6*

Colonies bright gray; sporangiophores 0.5 cm. high, at first erect, later frequently somewhat bending down, monopodially branched with branches again branched, or also, especially in young cultures, almost entirely unbranched; sporangia green-black with a trace of yellow, 50–80μ usually about 60μ in diameter, with dissolving wall; columella, in young sporangia, globose, later always more or less oval, 20–50μ usually 30–40μ in diameter, with small basal collar; spores rather uniform in shape, but very variable in size, usually regularly ellipsoidal, occasionally flattened on one side or slightly curved, 4–10 by 2.5–5μ; chlamydospores numerous in the substratum, very irregular, pyriform, barrel-shaped, et cetera, seldom in the sporangiophores.

Heterothallic; zygospores on short, 1–2 mm. high, nonseptate hyphæ that arise from the substratum, globose, 70–100μ usually 80–90μ in diameter, warty; warts very close-standing, short-rayed, starlike, black, opaque; suspensors rather short and thick, uniform, usually straight, the one (seldom both) in certain stages of conjugation with strong red-brown contents.

Hab. Isolated frequently from soil near Christiania, Norway, Hagem; Switzerland, Lendner; Czarnohora, Austria, Namyslowski; plant-breeding plats, Cornell University, by the writer. Plant pathology herbarium No. 5,897.

Mucor microsporus Namyslowski, Studien über Mucorineen. Bul. Acad. Sci. Cracovie, Series B. Sci. Nat., 518. June, 1910.

Colonies whitish, with age becoming yellowish, especially when grown on pears; mycelium cottony; sporangiophores unbranched, up to 2 cm. high, 12–20μ thick, below the columella strongly attenuated; sporangia brownish, 30–80μ in diameter, mostly 60μ; membrane of young sporangia does not dissolve in water, with age, however, it dissolves; columella spherical, somewhat higher than broad, beneath weakly attenuated, always with flat base and short collar; smooth, 20–70μ broad, often filled with

brick-red contents; spores regularly ellipsoidal, hyaline, smooth, 2–3μ long, 1.5μ broad (maximum 4μ long), in mass when young ashen-gray, with age bluish.

Hab. Isolated from meadow soil, Czarnohora, altitude 1,430 m., Galicia, Austria, Namyslowski.

Mucor adventitius Oudemans, Overdr. Nederl. Kruidk. Arch. ser. 3, 2: 3. 1903. Lendner, Les Mucorinées de la Suisse, 64. 1908.

Sporangiophores simple, continuous, hyaline, forming a sward 2 cm. high; sporangia globose, 80–95μ in diameter, at first hyaline then much later becoming clear gray, finely echinulate, provided with a diffluent membrane; columella at first globose, much later becoming ellipsoidal or campanulate, hyaline, measuring 40–48 by 48–64μ and provided with a basal collar; spores ellipsoidal or merely oblong, 8–8.5 by 4.5–5μ, smooth, hyaline, grayish black when in mass. Zygospores and chlamydospores not observed.

This species resembles *M. mucilagineus* Bref., from which it differs by its much smaller spores (8–8.5 by 4.5–5μ as against 30–33 by 15μ) and by the absence of intersticial mucilaginous protoplasm.

Hab. Isolated on exposed gelatin in the woods called Spanderswoud near Bussum, Holland, Koning.

var. *aurantiaca* Lendner, l. c.

Differs from species in containing guttulæ of a yellow-orange color.

Hab. Isolated from forest, Canton of Vaud, Switzerland, Lendner.

Mucor strictus Hagem, Untersuch. ü. Norw. Mucorineen 1: 18–19. *fig. 1.* 1908; reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 1907. Lendner, Les Mucorinées de la Suisse, 97–98. 1908.

Sporangiophores erect, 1–4 cm. high, 25–40μ thick, forming dense silver-white colonies, unbranched or also frequently with a single branch, mostly nonseptate; sporangia at first wax-like white, at maturity black, 200–300μ in diameter, fine-spiny; membrane dissolving, leaving at base of columella a collar; columella seldom globose, mostly oval or ovate with somewhat smaller base, in young sporangia with fine granular contents, in mature sporangia mostly without contents and with smooth membrane, 100–160μ high and 80–140μ broad, spores variable, seldom globose or oval, of 3.5–7.5μ diameter, mostly, however, regularly cylindrical, almost twice as long as broad, 5–7μ long by 2.5–3.5μ broad; zygospores unknown.

Hab. Acid soil of spruce woods, Norway, Hagem.

Mucor mucedo (Linné p. p.) Brefeld. For synonymy and literature see Fischer in Rab. Krypt. Flora Abt. 4, 1: 186–190. 1892. Hagem, Untersuch. ü. Norw. Mucorineen 1: 18. 1908; reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 1907.

Sporangiophores erect, with colorless membrane and colorless or weak-yellow scanty contents, forming a thick silver-gray glistening sward over the entire substratum, usually unbranched, 2–15 cm. long by 30–40μ thick, nonseptate, occasionally, especially the first from young mycelium, much shorter and with a side branch; sporangia large, globose, 100–200μ in diameter, at first yellowish, later when dry becoming dark gray or black-brown, occasionally with greenish shimmer, thick fine-spiny; sporangial wall quickly dissolving, leaving generally a basal collar; columella high-cylindrical or bell-shaped or globose, 70–140μ high by 50–80μ broad, with smooth, colorless membrane and mostly with orange-yellow contents; spores round cylindrical to long ellipsoidal, twice as long as broad, very uniform in shape, variable in size 6–12 by 3–6μ (extreme forms 16.8μ long), with colorless smooth membrane, weak-yellow or colorless contents.

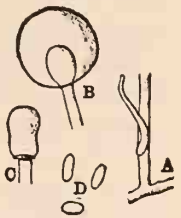

FIG. 104.—*Mucor mucedo (Linné) Bref.* A, *part of sporangiophore, showing occasional branching, x 60;* B, *sporangium, x 60;* C, *columella, x 60;* D, *spores, x 236.6*

Heterothallic; zygospores globose, 90–250μ in diameter; exospore black, with thick projecting tubercles; endospore colorless; contents colorless, with large oil drop; zygospores in our cultures not observed.

Hab. Isolated from soil by Hagem, near Christiania; Cracovie, Austria, Namyslowski; Germany, Adametz; by the writer frequently from oat field and experimental plats of Plant-Breeding Department, New York State College of Agriculture, Cornell University, Ithaca, N. Y. Plant pathology herbarium No. 5,898.

Racemo-mucor

Mucor Christianiensis Hagem, Neue Untersuch. ü. Norw. Mucorineen. Ann. Myc. 8: 268–272. *figs. 2–3.* 1910.

Colonies on agar consisting first of a thick gray mycelial membrane covering the surface of the substratum, finally there occurs a sparse formation of sporangiophores. Sporangiophores mostly scattered, seldom forming loose tufts 1.5–2.5 cm. high, generally thin 6–10μ thick and therefore soon falling, when young unbranched, older monopodially branched with few short upward-bent branches, with numerous chlamydospores, at maturity finally breaking into pieces. Chlamydospores in the sporangiophore at first cylindrical, later barrel-shaped or mostly spherical, rather regularly interspersed every 50–200μ, at maturity quickly becoming ripe and free. Sporangia small, usually 40–60μ in diameter, at maturity of bright yellow color, with wall that breaks, leaving finally only a collar at the base of the columella. Columella oval or mostly ovate, toward

the broad flat base somewhat cylindrical, always higher than broad, 30–45μ, occasionally 50μ high and 20–40μ broad, usually 25–30μ. Spores broad, oval, or also a few almost globose (4–5–)6–9(–12) by (4–)5–7(–9)μ. Zygospores unknown. Does not invert cane sugar.

Hab. Isolated several times from garden and flowerpot soil in the Botanical Gardens of Christiania, still very rare, Hagem.

Mucor dispersus Hagem, Neue Untersuch. ü. Norw. Mucorineen. Ann. Myc. 8: 272–275. *figs. 4–6.* 1910.

Sporangiophores forming none or slightly dense tufts (rasen) of different heights; the greater, 2–3 cm. high, very scattered, ascending, extremely thin (4–)5–7(–9)μ thick, waving to and fro, mostly soon dropping down, clustered, monopodially branched, with short, reflexed, frequently one-time-branched branches, chief branches as well as twigs ending in sporangia; the smaller, 1–2 mm. high, mostly reflexed, with small sporangia. End sporangia of the taller sporangiophores small, 50μ, with easily dissolving wall and smaller, usually blunt and broad spherical, seldom oval, columella (14–15–)17–19(–21)μ high and (14–15–)18–21(–27)μ broad. Basal collar present.

Sporangia of the side branches, as well as those of short sporangiophores, of very different size, 15–45μ, spiny, with nondiffluent membrane, with transparent spore mass that is frequently very small, 15μ, and containing only 2–4 spores, but also greater spore mass 30–45μ with numerous spores, mostly falling closed and remaining intact for a long time.

Spores of variable dimensions (9–10–)11–13(–15–18)μ, usually round or slightly long, sometimes roundish angled. Substratum mycelium, with peculiar long, frequently 100–200μ thick, swellings filled with oil drops.

Heterothallic; zygospores unknown. Hybridizes with *M. lamprosporus* Lendner. Inverts saccharose.

The swellings are very characteristic. The oil drops form near a septum, back of this is then laid down another septum.

Hab. Isolated only once in Norway from the deep soil. Closely related to *M. lamprosporus* Lendner.

Mucor sylvaticus Hagem, Untersuch. ü. Norw. Mucorineen **1**: 1–34. *figs. 11–12.* 1908; reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 1907. Lendner, Les Mucorinées de la Suisse, 74–75. *fig. 26.* 1908.

Colonies gray-white; sporangiophores erect, forming a dense growth over the entire substratum, 1–15 cm. high, always sympodially branched, with alternating right and left sporangial stalks that are separated from the further growing branches by a septum at the base; sporangial stalks straight, only seldom slightly curved, 200–500μ long, ascending, forming an angle of 30–50° with the chief axis of the sympodium; sporangia never sessile, yellow-green to weak black-green, globose, 45–70μ in diameter

with more or less plain basal collar and likewise as the sporangial stalk with smooth wall and colorless contents; spores oval or subcylindrical, 4 by 2μ or 5 by 3μ (to maximum 8 by 6μ).

Heterothallic; zygospores produced ladder-like on the sporangiophores, black, opaque, with plate-like, slightly raised elevations; azygospores numerous, seldom single, mostly double.

Hab. Isolated frequently from acid soil of forests near Christiania, Norway, Hagem.

Mucor racemosus Fresenius, Beitr. Myc. 12. 1850. Fischer, Rab. Krypt. Flora Abt. 4, 1: 192–194. 1892. Hagem, Untersuch. ü. Norw. Mucorineen 1: 24. 1908; reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 1907. Lendner, Les Mucorinées de la Suisse, 77. 1908.

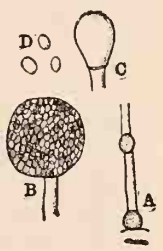

FIG. 105.—*Mucor racemosus Fres.* A, *part of sporangiophore, showing chlamydospores, x 236.6;* B, *sporangium, x 236.6;* C, *columella, x 236.6;* D, *spores, x 236.6*

Sporangiophores rigid, erect, 5–40 mm. long by 8–20μ thick, branched, with side branches sometimes branched; in mass dirty light yellowish; sporangia small, spherical, 20–70μ in diameter, erect, single, often reflexed, dirty yellow, wax yellow, or yellowish brown, transparent, sporangial wall smooth, not dissolving in water, but breaking open, often remaining long intact; columella hyaline, broad clavate to short ovate, 14–60μ long by 7–45μ broad, occasionally spherical or broad campanulate, with colorless smooth membrane; spores hyaline to dirty yellow, short ellipsoidal to globose, sometimes somewhat angled, variable in size 4–8 by 4–10μ, smooth.

Heterothallic; zygospores globose, 70–85μ in diameter, brown, warty exospore, suspensors smaller than spore; chlamydospores globose to oblong, globose measure 10–20μ, oblong 10–20 by 25–30μ, hyaline or yellowish guttulate, thick, smooth membrane.

Hab. Isolated from sandy and loamy arable soil, Germany, Adametz; from sandy-loamy soil from potato field, Long Island, N. Y., by the writer. Plant pathology herbarium No. 5,899.

Mucor flavus Bainier, Sur quelques espèces de Mucorinées nouvelles ou peu connues. Bul. Soc. Myc. France 19: 158. 1906. Hagem, Untersuch. ü. Norw. Mucorineen 1: 21–22. *fig. 3.* 1908; reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 1907. Lendner, Les Mucorinées de la Suisse, 79. 1908.

Sporangiophores attain on sterilized bread a height of 6 cm. and are usually 25–35μ thick, monopodially branched with long ascending branches that are again occasionally branched, in young cultures colorless, in old, yellow; sporangia at first white, then becoming blue-gray and finally yellow; columella in young sporangia frequently globose, in mature spo-

rangia, however, always oval or ovate with somewhat smaller base, 75–110μ high by 60–90μ broad; spores are rather uniform in shape, mostly oval or ellipsoidal, seldom cylindrical, occasionally somewhat flattened or curved, twice as long as broad, very variable in size, 5–12 by 3–6μ (mostly 9–10 by 4–5μ). There occur besides also in the cultures globose spores 4–5μ in diameter; zygospores not observed.

Hab. Isolated from forest soil near Christiania, Norway, Hagem; Switzerland, Lendner.

Mucor genevensis Lendner, Bul. Herb. Boissier No. 1, 8: —. 1908; Les Mucorinées de la Suisse, 80–82. *fig. 27*. 1908. Hagem, Neue Untersuch. ü. Norw. Mucorineen. Ann. Myc. 8: 275–277. *fig. 7*. 1910.

Colonies with rich or sparse formation of sporangiophores; sporangiophores erect, monopodially branched with longer or shorter side branches, rather thin, 8–15μ thick, usually 1–2 cm. high, ending in sporangia. Sporangial membrane easily dissolving in water, usually there remains on the columella an irregular basal collar. Columella colorless, hyaline, either more or less spherical or also oval to obovate, 20–40μ high, 20–35μ broad. Spores small, ellipsoidal, usually twice as long as broad, (4–)5–7(–9–10)μ long and (2–)2.5–3.5(–4)μ broad, almost hyaline.

Homothallic; zygospores produced between especially low (1 mm. high) zygophores. Suspensors as well as gametic cells almost of the same size and form, or slightly different. Zygospores spherical or laterally somewhat compressed; immature ones yellow-brown, transparent, mature ones black and opaque with rather high, starlike, thickened tubercles (60–)70–90(–100)μ high and (45–)60–70(–90)μ wide.

Hab. Found in Norway but once. Isolated from the soil of a fir wood in the neighborhood of Hauersaeter railroad station, Hagem; by Lendner in neighborhood of Geneva, Switzerland, from soil.

This species claims an especial interest because of the monœcious nature of its mycelium. The zygospores are always richly developed in culture. Hagem established this by repeated cultures from a single spore.

Cymo-mucor

Mucor botryoides Lendner, Nouvelles Contributions à la Fl. Crypt. Suisse. Bul. Soc. Bot. Genève ser. 2, 2: 79–81. *fig. 4*. 1910.

Sporangiophores nonerect, incurved, forming a cobwebby network, attaining 1.5 cm. in height, not varying far from 16 to 20μ in diameter, ending in a large sporangium and producing at a short distance below the sporangium more or less closely clustered branches that are terminated by sporangia; secondary branches are sometimes dichotomous or sometimes in sympodia; sporangia globose, clear gray, with membrane of the large as well as the small sporangia diffluent in water, average size of the terminal

80μ in diameter; the lateral sporangia are variable and some are very small; columella variable in form and size, hyaline, globose, campanulate or panduriform, 60 by 44μ, or 55 by 38μ, or 30 by 20μ, and much smaller, usually without basal collar; spores hyaline, globose, average 8μ, maximum 10μ, not rarely encountered as small as 5–6μ; appearing polyhedral because of their surface presenting very slight roughness.

Hab. Isolated from soil, Geneva, Switzerland, Lendner.

var. **minor** n. var.

Differs from species in having brownish black sporangia, thicker sporangiophores (up to 30μ), and in the smaller spores, which appear perfectly smooth. Spores average 6μ in diameter, extremes 8μ and 4.5μ; chlamydospores of mycelium lemon-shaped, 16–22 by 10–16μ.

Hab. Isolated from soil of plant-breeding plats, Cornell University, November and December, 1910, and from flowerpot soil from horticultural greenhouses, March, 1911, Ithaca, N. Y., by the writer. Plant pathology herbarium No. 5,900.

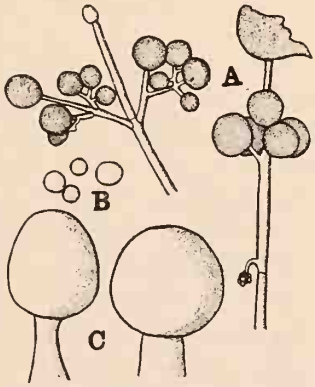

FIG. 106.—*Mucor botryoides Lendner var. minor.* A, *sporangiophores, showing sporangia and method of branching, x 90;* B, *spores, x 355;* C, *columellæ, x 355*

Mucor lamprosporus Lendner, Bul. Herb. Boissier No. 1, 8:—. 1908; Les Mucorinées de la Suisse, 92–93. *fig. 33.* 1908.

On 10 per cent wort-gelatin, the colony forms a pale gray, dense sward 3 cm. above the substratum; sporangiophores very irregularly branched in clusters or sympodia. Part of the branches situated at the level of the substratum carry the small circinate sporangia (30–40μ in diameter), which are indehiscent and deciduous. When they are numerous, the substratum appears velvety and greenish black; the large sporangia are diffluent in water, leaving a basal collarette, 60μ in diameter (maximum 90μ); columella globose or ovoid, often broader at the base than at the summit, 20μ in diameter, or 24 by 28μ; spores hyaline, transparent, very refringent, globose, large, mean diameter 10μ, maximum diameter 12μ, minimum 7μ.

Hab. Forest soil, summit of Vuache, Savoie, Lendner.

Mucor circinelloides van Tieghem, Nouvelles Recherches sur les Mucorinées. Ann. Sci. Nat., Bot. Ser. 6, 1: 94. 1875. Fischer, Rab. Krypt. Flora Abt. 4, 1: 204. 1892. Hagem, Untersuch. ü. Norw. Mucorineen 1: 34–37. *fig. 13.* 1908; reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 1907.

Sporangiophores of different form and different height, shorter, mostly 2–5 mm. high, pure sympodially branched; branches usually 5–6, alternating right and left, short, often appearing as sessile, straight or slightly bent or curved; longer sporangiophores 0.5–1.5 cm., irregularly monopodially or sympodially branched; sporangia globose, at first light brown then becoming gray-brown, those of longer sporangiophores with dissolving membrane while those of the shorter possess a firm membrane and often fall intact; membrane either finely spiny or smooth; columella sessile, globose, hyaline, smooth, 15–42μ in diameter depending on size of sporangium; spores oval or broad ellipsoidal, 3–4 by 5–6μ, smooth, singly hyaline, in mass weak gray.

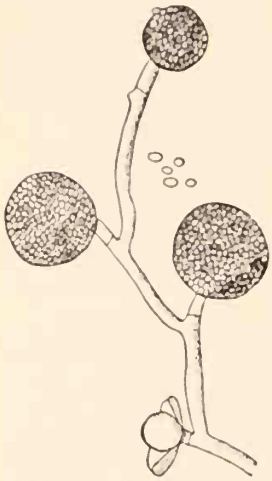

FIG. 107.—*Mucor circinelloides van Tiegh. Showing method of branching of sporangiophore, sporangia, columella with collar, and spores, x 230.6*

Heterothallic; zygospores globose; exospore red brown, with long thorn-like pointed warts that are streaked longitudinally; chlamydospores intercalary, barrel-shaped, smooth, hyaline. Zygospores not observed in our cultures.

Hab. Isolated in July, 1910, and March, 1911, from oat field and experimental plats of Plant-Breeding Department, Cornell University, Ithaca, N. Y., by the writer. Plant pathology herbarium No. 5,901.

Mucor griseo-cyanus Hagem, Untersuch. ü. Norw. Mucorineen 1:28–29. *fig. 9.* 1908; reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 1907. Lendner, Les Mucorinées de la Suisse, 86–87. *fig. 29.* 1908.

Colonies grown at room temperature (15° C.) blue-gray, at 20–25° C. deep black-blue; sporangiophores at first erect, soon, however, sinking down, 2–3 cm. long, 8–12μ thick, sympodially branched with branches again richly branched, generally with a septum on the main branch just above place of origin of side branches; sporangia globose, at maturity deep blue-black, opaque, with spore mass invisible, 60–80μ in diameter; sporangial wall blue-gray to blue-black, incrusted, dissolving, breaking, or remaining intact; columella mostly globose, seldom somewhat oval, 30–45μ in diameter, with smooth membrane and colorless contents; spores oval or broad ellipsoidal, 4–6 by 2.5–4μ; zygospores unknown.

Hab. Isolated from humous soil near Christiania, Norway, Hagem; Canton of Geneva, Switzerland, Lendner.

Mucor corticolus Hagem, Neue Untersuch. ü. Norw. Mucorineen. Ann. Myc. 8: 277–279. *fig. 8.* 1910.

Colonies gray or weak blue-gray. Sporangiophores erect, up to 2 cm. high, sympodially branched with few long branches, ending in a sporangium. Side branches long (2–3 times as long as with *M. sylvaticus*), usually 600–1,500μ long by 10–15μ thick, frequently more or less reflexed and ending in sporangia. Sporangia spherical, 50–60 (–70)μ in diameter, with quickly dissolving membrane. Columella ovate or suboval, almost always 3–6μ higher than broad, 27–33μ broad and 30–36μ high, with or without colorless contents and usually with an inconspicuous basal collar. Spores oval or ellipsoidal (larger than with *M. sylvaticus*), 5–7 (–8) by 3.5–5 (–6)μ. Zygospores unknown.

Hab. Especially numerous in old decaying bark of conifers, and in old wood as well, seldom in the soil, Norway, Hagem.

Mucor Jansseni Lendner, Bul. Herb. Boissier ser. 2, **7**: —. 1907. Les Mucorinées de la Suisse, 88–89. *fig. 30.* 1908.

Sporangiophores 2–6 mm. high, branched in corymbs or sympodia with each branch ending in a sporangium, with membrane having oblique striæ; sporangia dark bluish black, 50–70μ in diameter, with finely granulated, nondissolving, but fracturing, membrane; columella sometimes spherical with widened flat sessile base, sometimes more elongated and conical, dark black or grayish, maximum 30μ broad by 34μ long, the smaller proportionately longer, measuring 20μ broad by 26μ long; spores globose, generally 5 to 6μ in diameter, the smallest 3–4μ in diameter.

Hab. Soil of the Janssen Cabin, summit of Mt. Blanc, 4,810 m., summer 1906, Lendner.

Mucor plumbeus Bonorden, Abh. Naturf. Gesell. Halle **8**: 109. 1864.

Syn *Mucor spinosus* van Tieghem, Ann. Sci. Nat. ser. 6, **4**: 390. 1876.
Mucor aspergilloides Zopf, Verh. Bot. Ver. Brandenb **23**: 22. 1881.

Sporangiophores rigid, erect, thick, up to 1 cm. high, mixed monopodially and cymose-sympodially branched with all branches ending in sporangia, straight, seldom bending or reflexed, with a septum at the base, with hyaline smooth membrane, hyaline contents; sporangia globose, small, up to 100μ in diameter, at first hyaline, at maturity dark brown or black, finely spiny, membrane dissolving, basal collar; columella sessile, long cylindrical or pyriform, with one or more irregular, straight or bent spines on the summit, 22–85 by 8–65μ, membrane weak smoke-gray or brownish, contents hyaline; spines up to 5μ in length; spores globose, yellow-brownish, exospore with irregular folds. Chlamydospores are not infrequent as with *M. racemosus*, also on the sporangiophore up to the columella.

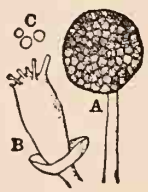

FIG. 108.—*Mucor plumbeus Bonord.* A, *sporangium, x 236.6;* B, *columella, showing collar and spines, x 236.6;* C, *spores, x 236.6*

Hab. Isolated from soil of plant-breeding experimental plats, Ithaca, N. Y., by the writer, in November, 1910; also by Hagem in Norway. Plant pathology herbarium No. 5,902.

Mucor sphaerosporus Hagem, Untersuch. ü. Norw. Mucorineen **1**: 22–24. *fig. 4.* 1908; reprint from Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 1907. Lendner, Les Mucorinées de la Suisse, 92. 1908.

Colonies yellow-brown or brown; sporangiophores of very different height, partly short only 1–2 mm. high, partly up to 1 cm. high; the latter, however, frequently scattered or united in clusters, at first erect, soon, however, especially in the upper half, sinking down, richly monopodially branched with long, repeatedly branched branches; sporangia globose, 70–110μ in diameter, yellow-brown, with easily dissolving wall; columella ovate, toward the base somewhat attenuated, 40–65μ high by 30–55μ broad, with mostly weak yellow-brown thick membrane; spores globose, variable in size even in the same culture, 10(6–8)μ in diameter, solitary or in mass slightly yellow; chlamydospores in the sporangiophores with a large central oil drop; zygospores unknown.

Hab. Isolated from soil, Christiania, Norway, Hagem.

Mucor dimorphosporus Lendner, Bul. Herb. Boissier **8**: —. 1908; Les Mucorinées de la Suisse, 93–94. *fig. 34.* 1908.

Colonies on wort-gelatin grayish, attaining a height of 2 cm. above the substratum; sympodially branched sporangiophores straight, 2 cm. long, 12μ thick. Near the substratum are found other sporangiophores that are wavy and even circinate, carrying much smaller sporangia. Normal sporangia spherical, maximum 80μ, often wider than high, mean 60μ wide by 58μ high; membrane diffluent; spores ordinarily globose, 8–10μ in diameter, often also oval 6 by 8μ or 8 by 10μ, hyaline or light yellowish, brilliant. Abnormal spores measure up to 30μ long by 8–10μ wide, very irregular; columella often much larger toward the basal part, 20 by 24μ to 40 by 50μ, oval, surrounded by a collarette; chlamydospores ovoid. Zygospores unknown.

Hab. Soil of the Janssen Cabin, summit of Mt. Blanc, 4,810 m., summer 1906, Lendner.

Mucor geophilus Oudemans, Arch. Néerl. Sci. Nat. ser. 2, **7**: 278. *pl. 5, fig. 1.* 1902. Lendner, Les Mucorinées de la Suisse, 97. 1908.

Colonies at first white, later grayish, and finally dilute olive; vegetative hyphæ dichotomously branched, continuous, dilute olive, with homogenous protoplasm; fertile hyphæ concolorous, at first simple, then passing to cymose-branched, branches usually few (2–3), continuous; sporangia globose, at first yellowish, afterward olive, dissolves leaving a basal collar, 50–350μ in diameter, spiny; columella exactly spherical, large, very dilute fuliginous; spores pluriform, globose, angular, or ellipsoidal, 4.2–6.5μ in

diameter, very dilute olivaceous, smooth; chlamydospores in the myeelial branches interealary, globose, with granular protoplasm, 20μ in diameter, sometimes solitary and sometimes in aggregations. Zygospores as they are seen are somewhat similar to chlamydospores, being slightly larger.

Hab. Isolated from soil of woods called Spanderswoud near Bussum, Holland, Koning.

Mucor saturninus Hagem, Neue Untersueh. ü. Norw. Mueorineen. Ann. Myc. 8: 265. 1910.

Colonies always more or less dark-colored, usually lead-gray or lead-black, occasionally, however, also blue-black. Sporangiophores in the same colony of very different heights, part lower and part higher, the lower only 1–2 mm. high, usually riehly but irregularly monopodially or sympodially branehed, and lead-blaek or blue-black tufts are formed as a consequence of the large sporangia, the higher (2–3 cm. high sporangiophores) are more or less seattered, 20–25μ thiek and at the beginning erect, later somewhat bent, eurved, monopodially branehed with long braneh es and of a eharaeteristie height, lead-gray eolor (saturninus); sporangia of the lower sporangiophores at first bright wax-yellow, then blue-gray, and at maturity almost black, of very different sizes, usually 45–180μ in diameter, with a plain, spiny membrane that remains intaet in water or breaks; sporangia of the higher sporangiophores, on the eontrary, have membranes that easily dissolve in water, leaving a collar at the base of the columella. Columella oval or ovate, seldom more eylindrieal in the sporangia of the higher sporangiophores, frequently toward the base smaller, 60–100μ high by 50–90μ broad, in the sporangia of the lower or shorter sporangiophores, on the contrary, somewhat smaller, 35–70μ high by 25–50μ broad. Spores regularly broad ellipsoidal, extremes 4.5–10 by 3.5–7μ usually 6–8 by 4–6μ. In addition there are frequently single small spherieal spores 4–4.5μ in diameter. Zygospores unknown.

Hab. Rare. In the upper humous layers of soil in Norway, Hagem.

Zygorrhynchus

Zygorrhynchus Vuilleminii Namyslowski, Zygorrhynehus Vuilleminii une Nouvelle Mueorinée Isolée du Sol et Cultivée. Ann. Myc. 8: 152–155. *figs. 1-9.* 1910.

The fungus develops more luxuriantly on bread than on agar. It eovers the bread with a thiek felt and tuft of hyphæ that attain 0.5 em. in height. The hyphæ at first are white, later they beeome gray. On agar, the myeelium is eottony, at first white, then gray, and black with age.

Sporangiophores are hyaline, smooth, flexible, pendant or straight, septate, 5–14μ in diameter, variable in length; sporangia are spherieal, attaining a diameter of 70μ, ordinarily 30–50μ, terminal, in general, the

largest; membrane covered with needles of calcium oxalate, never dissolving in water when young, but does at maturity often leaving a basal collar; columella flattened oval, rarely spherical, ordinarily broader than high, breadth 12–30μ sometimes attaining 35μ; spores are ellipsoidal 2 by 4μ, hyaline, occasionally a few are globose 2.5 by 2.5μ.

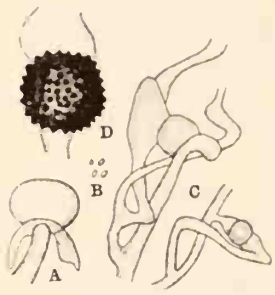

FIG. 109.—*Zygorrhynchus Vuilleminii Namy.* A, *columella and collar, x 236.6;* B, *spores, x 236.6;* C, *showing method of formation of zygospores, x 236.6;* D, *mature zygospore, x 236.6*

Chlamydospores (developed in mycelium) solitary or in chains, size and form variable; the ovoid or spherical ones are on the average 12 by 20μ, the barrel-shaped 40 by 14μ and ordinarily united in chains. Zygospores formed from copulation of two unequal gametes, (20–)40–50 (–60)μ, the exospores brownish, covered with tubercles 2–3μ high and truncate. Azygospore frequently and often irregularly developed on the ends of solitary hyphæ, which continue to grow and produce a second azygospore, polymorphic and always smaller than the zygospore.

Hab. Isolated from Montenegro soil by Namyslowski; by the writer from the plant-breeding experimental plats of Cornell University, Ithaca, N. Y., April, 1911. Plant pathology herbarium No. 5,903.

Description is after Namyslowski's except as to height of hyphæ on bread, diameter of sporangiophores, disposition of the tubercles on the exospores, and size of the sporangia. The author found the culture attaining a height of 0.25 cm. on bread; our culture attains a height of 0.5 cm.; sporangiophores are 5–14μ as against 5–8μ. Sporangia show maximum of 70μ as against 60μ, with the tubercles varying in arrangement from groups to no groups at all. The original description claims groups only. For these reasons the species is emended as given in this description.

Zygorrhynchus Moelleri Vuillemin, Importance taxinomique de l'appareil zygospore des Mucorinées. Bul. Soc. Myc. France, **19**: 117–118. 1903.

Differs from *Z. Vuilleminii* only in the size of the spores. Spores are ellipsoidal, straight or slightly curved, 3 by 5–7μ.

We have retained these two species in this work, and leave to the special student of the Mucorineae whether they shall be so considered or whether they are to be taken as varieties of one species. These cultures have been carried on similar media for many months and still retain this constancy.

Hab. Isolated from soil shipped from East Hampton, Long Island, N. Y., October, 1910, by the writer; also in Norway by Hagem. Plant pathology herbarium No. 5,894.

Family Thamnidiaceae

Thamnidium elegans Link, Observ. in Ord. Plant. Nat. 1: 45; Berliner Magaz. Naturf. Freunde 3: 21. 1809. Fischer, Rab. Krypt. Flora Abt. 4, 1: 241–244. *fig. 41.* 1892.

Sporangiophores erect, ending in large sporangia. Below these, in the middle or under part of the sporangiophore are generally 2–5 verticillate horizontal side branches that are forked several times (2–10) after an obtuse-angled fashion. The branchlets finally end in sporangioles. The whole sporangiophore is usually 0.5–3 cm. occasionally 6 cm. high by 25–35μ thick. The white floccose group of forked verticillate branches are relatively very small, 0.25–1 mm. broad. The main verticillate branches up to the forking are 150–200μ long by 8μ thick; the forks of the first order are 40–60μ long; the forks of the last order are only 4–6μ long by 2μ broad. The membrane of the sporangiophore and its branches is colorless and smooth; contents are also colorless. Branching of the sporangiophore is very variable (see variation below). Chief sporangia (haupt-sporangia) globose, large, 100–200μ diameter, occasionally smaller, at maturity white with large ovate or bell-shaped, colorless, smooth columella; sporangioles globose, small, white, 8–16μ in diameter, mostly 4-spored, varying, however, from 1 to 10; spores of haupt-sporangia and sporangioles similar and equally large (except in the one-spored sporangioles where they are globose, 8–16μ), ellipsoidal, 8–10μ by 6–8μ, smooth, weak gray-brown. Zygospores are globose, black, with thick black warty exospore and yellowish endospore. Zygospores not observed in our cultures.

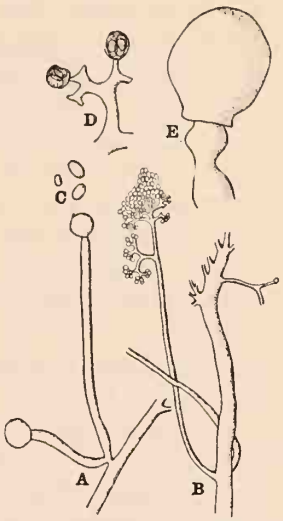

FIG. 110.—*Thamnidium elegans Link.* A, *sporangiophore and hauptsporangia, x 60;* B, *sporangiophore and nebensporangia, x 60;* C, *spores from nebensporangia, x 236.6;* D, *ultimate divisions of sporangiophore, with sporangioles, x 236.6;* E, *columella of haupt-sporangium, x 236.6*

Hab. Isolated from pepper root taken from soil of plant-breeding plats of Cornell University, Ithaca, N. Y., March, 1911, by the writer. Plant pathology herbarium No. 5,904.

Variation of sporangiophores.— The branching of the sporangiophores is very variable. In one extreme case the sporangiophore carries only the chief sporangium, when it resembles an ordinary Mucor; in the other case the chief sporangium is wanting, the sporangiophore ending then either with a crown of sporangioles or with a sterile tip. Occasionally the first

side branch ends in a sporangium, again the branches of the second order end thus, and again the number and order of the branching is manifold.

Family Pilobolaceae

Pilaira anomala (Cesati) Schröter, Schles. Krypt. Flora 3: 211. 1886.

Syn. *Pilobolus anomalus* Cesati, Rab. Herb. Myc. Ed. 1: 1542. 1851.
Ascophora Cesatii Coemans, Mem. Acad. Belg. 30: 63. 1861.
Pilobolus mucedo Brefeld, Untersuch. 1: 27. 4: 66. 1872.
Pilaira Cesatii van Tiegh. Ann. Sci. Nat., Bot. Ser. 1: 51. 1875.
Pilaira Cesatii Bainier, Etude, 29. 1882.
Pilaira Cesatii Grove, Midland Nat. 1884: 37.
Pilaira anomala Berlese & de Toni, Sacc. Syll. Fung. 7: 188. 1888.

Sporangiophores at first erect but soon falling and forming over the whole substratum a high, loose, hyaline, woolly, interwoven mass, usually 10–12 cm. long but even attaining 20 cm., cylindrical, 30–80μ thick, without basal and subsporangial swelling, with colorless, thin, slightly wavy membrane, at the time of maturity of spores without contents. Sporangium at first white, then becoming yellow and finally at maturity black, with colorless base, when moist globose, 100–250μ in diameter, when dry half-globose, many-spored; columella 100–150μ broad by 40–60μ high, depressed half-globose or knot-like, smooth, colorless; spores long oval, 8–13 by 5–8μ, solitary, hyaline, in mass yellowish, with colorless thin smooth membrane; zygospores at maturity black, round or slightly oval, 120μ long by 100μ broad, with smooth thick colorless endospore and black warty epispore, germination with short sporangiophore.

Hab. Isolated from forest soil, Holland, Koning.

Family Mortierellaceae

Mortierella subtilissima Oud., Contrib. Fl. Myc. des Pays-Bas ser. 2, 19: 876. 1901; Arch. Néerl. Sci. Nat. ser. 2, 7: 277–278. *pl. 4, figs. 1–3.* 1902. Lendner, Les Mucorinées de la Suisse, 156. 1908.

Colonies similar to *M. pusilla*, vegetative hyphæ, hyaline, continuous, branched, 3–5μ thick, with homogenous protoplasm; fertile hyphæ strict, continuous, hyaline, 130–200μ thick, simple, cylindrical, not thickened downward nor hardly attenuate upward, ending singly in sporangia; sporangia globose, smooth, 20–30μ in diameter, membrane hyaline; spores smooth, hyaline, 2.3–4.6μ in diameter, commingled with elliptical ones 5–6 by 4–5μ.

Hab. Isolated from humous soil from Spanderswoud near Bussum, Holland, March, 1901, Koning.

Differs from *M. pusilla* in vegetative hyphæ having homogenous, never granulate, protoplasm; in the slender conidiophores (2.3–3.5 against 5μ) being equally thick their entire length; in the sporangia being smaller

(20–26μ against 24–28μ), and the smaller globose spores commingled with the larger elliptical ones.

Mortierella pusilla Oud., Contrib. Fl. Myc. des Pays-Bas ser. 2, **19**: 876. 1901; Arch. Néerl. Sci. Nat. ser. 2, **7**: 277. *pl. 3, fig. 1.* 1902. Lendner, Les Mucorinées de la Suisse, 155–156. 1908.

Colonies orbicular, constantly snow-white, floccose with few superposed layers that are repand or lobate, the layers diminish in number toward center; vegetative hyphæ hyaline, 2.5–10μ thick, dichotomously branched, with protoplasm dense and full of minute granules; fertile hyphæ, 4–6μ in diameter, downward slightly thickened, upward slightly attenuate, 130–170μ high, terminating singly in sporangia; sporangia globose, smooth, 24–28μ in diameter, membrane hyaline; spores globose, smooth, hyaline, 2–2.5μ in diameter, variously guttulate to not at all.

Hab. Isolated from humous soil from Spanderswoud near Bussum, Holland, March, 1901, Koning.

Differs from *M. isabellina* in colonies having lamellate texture and being constantly white; in vegetative hyphæ having dense protoplasm that is full of minute granules; in conidiophores being attenuate toward tip; and in having hyaline spores.

Mortierella isabellina Oud., Contrib. Fl. Myc. des Pays-Bas ser. 2, **19**: 875. 1901; Arch. Néerl. Sci. Nat. ser. 2, **7**: 276. *pl. 2, fig. 1.* 1902. Lendner, Les Mucorinées de la Suisse, 156–157. 1908.

Colonies zonate, at first white, then bright gray, finally isabel-colored (Sacc. Chromot. No. 8), somewhat rougher with age; vegetative hyphæ dichotomously branched, continuous, with protoplasm equally dense; fertile hyphæ erect, cylindrical, upward slightly more slender, continuous, 120–200μ high, hyaline, ending singly in sporangia; sporangia globose, 12–15μ in diameter, smooth, membrane hyaline; spores globose, smooth, solitary, almost hyaline, in mass very dilute pale yellow, 2–5μ in diameter; chlamydospores submerged in medium, spherical to elliptical, smooth, hyaline, membrane thin.

Hab. Isolated from humous soil from Spanderswoud near Bussum, Holland, March, 1901, Koning.

Differs from *M. simplici* in the color of the colonies when in state of active growth; in color and dimensions of spores (2–5 against 10μ), also in their enucleate condition.

Mortierella humicola Oud., Contrib. Fl. Myc. des Pays-Bas ser. 2, **19**: 875. 1901; Arch. Néerl. Sci. Nat. ser. 2, **7**: 276. *pl. 1, figs. 1–3.* 1902. Lendner, Les Mucorinées de la Suisse, 56. 1908.

Colonies orbicular, nonlamellate, constantly snow-white; vegetative hyphæ dichotomously branched, hyaline, continuous, everywhere with swellings, with protoplasm full of small granules; fertile hyphæ perfectly

cylindrical that is, not thickened toward the base nor attenuate toward the top, with protoplasm greatly vacuolated, 110–150μ high, unbranched and ending singly in sporangia; sporangia globose, 20μ in diameter, smooth, membrane hyaline; spores globose, smooth, up to 3μ in diameter, hyaline, from variously nucleate to not at all guttulate.

Hab. Isolated from humous soil from Spanderswoud near Bussum, Holland, March, 1901, Koning.

Suborder Conidiophorae

Family Chaetocladiaceae

Cunninghamella elegans Lendner, Bul. Herb. Boissier ser. 2, 5: —. 1905; Les Mucorinées de la Suisse, 159–161. *figs. 58–59.* 1908.

Mycelium white (very slightly ashen), of two kinds: the first, in contact with the substratum, is very compact and in old cultures it forms a cartilaginous layer in which it takes on a pseudo-parenchymatous appearance; the other part, the aerial, is cottony; conidiophores erect, dichotomously branched, with or without septa; apex of conidiophore terminating in a very regular head; head round or slightly oval or pyriform, measuring as much as 60μ in diameter, minutely verrucose. Below the terminal head is a branch or verticil of branches of variable number, each terminated by a round head of mean diameter 18–20μ; conidia variable in size and shape; those of the terminal head being larger, ovoid, minutely verrucose, 16 by 12–14μ (maximum 14 by 22μ); those of the lateral heads smaller and more globular, 8–10μ in diameter, in color very pale blue ashen, falling easily at maturity.

Hab. From garden soil near Geneva, Switzerland, and Vuache, Savoie, Lendner.

Family Saprolegniaceae

Aphanomyces laevis de Bary, Jahrb. Wiss. Bot. 2: 179. 1860. Fischer, Rab. Krypt. Flora Abt. 4, 1: 358. 1892. Humphrey, J. E., The Saprolegniaceae of the United States with Notes on Other Species. Trans. Amer. Phil. Soc. Philadelphia 17: 128–129. 1892.

Colonies thick, up to 1 cm. broad, very tender and inconspicuous, with long, unbranched, very weak and thin chief branches, which are only 5–7μ thick. Zoosporangia terminal, thread-like, often very long (up to 2 mm.), containing only one row of swarm spores (20–100, mostly 100, swarm spores), never or only seldom renewed by proliferation after the liberation of the swarm spores. Swarm spores relatively large, up to 20μ long. Oogonia terminal on short lateral branches, globular, 25–35μ in diameter, with entirely smooth membrane. Antheridia abundantly developed on all oogonia, large clavate-cylindric, on short branches of androgynous or

diclinous origin, sometimes even from the oogonial branch; oospores single, globular, concentric, 20–22μ in diameter.

Hab. Soil saprophyte, parasite on beet (Busse, Peters, Ulrich) and on decaying insects in water.

Pythium de Baryanum Hesse, Inaug. Diss. Halle. *pls. 1–2.* 1874. Butler, Mem. Dept. Agr. India No. 5, 1: 86–91. 1907.

Mycelium rather coarse, intra- and extramatrical. Hyphæ large, branching irregular and free, septate in old cultures. Sporangia spherical or oval, chiefly extramatrical, terminal and intercalary; supporting hyphæ usually emptied of their contents for a variable distance below the sporangium, and separated by septa from the full part of the hyphæ and from the sporangium. Tube of discharge lateral, about the diameter of the sporangium in length. Proliferation is absent; conidia usually numerous, intra- and extramatrical, 15–25μ in diameter, round oval, or somewhat irregular in shape and size in old cultures, may germinate at once but more usually do so after a short rest if transferred into fresh water. Oogonia usually numerous, intra- and extramatrical, sometimes formed very early in culture, 20–25μ in diameter, spherical, terminal or intercalary. Antheridia up to 3 in number, from the same or another hypha as the oogonium, often formed close below the latter and not seldom hypogonal. Oospores 14–18μ in diameter, not filling the oogonium, spherical, smooth, germinating after a rest of some months by a branching hypha.

Hab. Saprophytic in soil, Europe, United States, Butler; Europe, Busse, Peters, and Ulrich. Parasitic on a number of seedling phanerogams and on prothallia of ferns and Equisetum, Europe, United States.

Pythium intermedium de Bary, Bot. Ztg. **39**: 554. *pl. 5, figs. 14–16.* 1881. Butler, Mem. Dept. Agr. India No. 5, 1: 6 and 96–99. 1907.

Syn. *Artotrogus intermedius* (de Bary) Atk., New York (Cornell) Agr. Expt. Sta. Bul. 94: 247. *pl. 2, figs. 10–25.* 1895.

Mycelium extra- and intramatrical, forming a regular fine haze around the substratum in water culture. Hyphæ very numerous, up to 6μ thick, regular, without intercalary swellings; branching often at right angles, sometimes dichotomous, more usually lateral. In old cultures septa, with a distinct double contour, are not uncommon. The tips of all free branches usually end in spores. They measure 18–24μ in diameter and are normally arranged in chains. When ripe they fall off readily and can germinate immediately in fresh water. (For manner of formation and position of spores see Butler.) Spores in the chain spherical or pear-shaped. These may germinate as sporangia or as conidia. In young cultures, large numbers of sporangia occur and discharge zoospores on addition of fresh water. In older ones the conidia are the organs chiefly found. The tube of discharge is always short, about one half the diameter

of the sporangium. The conidia are often provided with thick walls, showing a distinct double contour. Sexual organs have not been observed.

Hab. Saprophytic in garden soil, Cork, Kew, Great Britain; Paris, Antibes, France; and Freiburg i. Br., Germany, Butler. Parasitic in prothallia of Equisetum, Todea, and Ceratopteris, Germany. Parasitic in fern prothallia (not further specified). Cornell University, New York State, U. S. A., Atkinson.

Pythium vexans de Bary, Jour. Bot. 5: 119. 1876; Jour. Roy. Agr. Soc. England ser. 2, 7: 339. *fig. 6.* 1876; Bot. Ztg. 39: 537. *pl. 5, figs. 3–7.* 1881. Butler, Mem. Dept. Agr. India No. 5, 1: 91–94. *pl. 5, figs. 1–10.* 1907.

The mycelium is slender, finer than that of *P. de Baryanum* Hesse or *P. rostratum* Butler, but resembling *P. intermedium* de Bary both in the thickness of the hyphæ and the size of the thallus in water cultures. The branches of the secondary or tertiary order often extend far beyond the primary hyphæ, tapering into very fine filaments at the ends. This character distinguishes this species from all others.

Sporangia and conidia are developed on two- or three-days-old cultures. The former are rare. They occur both terminally and, more rarely, intercalarily, and are scarcely ever spherical or oval, but usually irregularly pear-shaped ovoid or subangular. The sporangial tube of discharge is short, and the zoospores are given only when the sporangia are sown immediately in fresh water. The sporangia and the conidia measure 17–24μ in diameter, averaging about 21μ. A second conidium is sometimes budded off from the first by a continuation of growth before the first is cut off by its basal septum. There are irregular intercalary swellings from which one or more branches arise.

The oogonia are 22–25μ in diameter. They arise laterally usually on short branches from the main hyphæ, or sessile on the latter. The oogonium is usually inserted on its stalk by a broad base. The antheridia usually arise from the oogonial stalk and are sometimes hypogonal. The antheridial cell is club-shaped or rounded, and large in relation to the oogonium. Oospores free in the oogonium, 20–22μ in diameter, smooth, round.

Hab. Saprophytic in garden soil, Cork, Kew, Great Britain; Antibes, France, Butler. Saprophytic in potatoes, Germany, de Bary.

Pythium proliferum de Bary, Jahrb. Wiss. Bot. 2: 182 *pl. 21.* 1860. Ward, H. M., Quart. Jour. Mic. Sci. n.s. 22: 497. *pls. 34–35, figs. 11–21.* 1893. Dangeard, Recherches histologiques sur les Champignons. Le Botaniste 2: 123. *pl. 6, figs. 39–48.* 1890. Butler, The Genus Pythium and Some Chytridiaceae. Mem. Dept. Agr. India No. 5, 1: 76–77. *pls. 3–4, fig. 1.* 1907.

Mycelium, in water cultures, fine. Hyphæ uniform, 4–5μ broad, branching lateral and sporulating in young cultures; sporangia terminal, spherical, rarely oval, vacuolated, very variable in size, 30–58μ in diameter, with short tube of discharge, rarely equaling one fourth of the diameter of the sporangium, placed in any position but usually opposite the stalk. After discharge, growth of the supporting hyphæ occurs through the emptied sporangium or immediately below it laterally, new sporangia being formed within the empty sporangium, or beyond it, in the first case. Zoospores large, 3 to numerous; conidia unknown; oogonia within and outside the substratum, terminal or often intercalary, 19–36μ in diameter. Antheridia 1–3 or more from neighboring branches and less frequently from the oogonial stalk. Oospores spherical, 16–27μ in diameter. Germination by a hypha after a rest of several months.

Hab. Found on dead insects in water and on vegetable debris in the soil, Antibes, Calcutta, Dehra Dun, Butler.

Pythium rostratum Butler, Mem. Dept. Agr. India No. 5, 1: 84–86. *pl. 5, figs. 11–22.* 1907.

Mycelium in water cultures is large, often measuring 6 or even 8μ in diameter, tapering gradually at the ends, but never prolonged into fine filaments, with branches irregularly racemose. Sporangia either terminal or intercalary, being almost regularly spherical in the former case but often oval in the latter, average 28μ in diameter, ranging from 23 to 34μ. Zoospores are normally liberated while the sporangium remains attached to its bearing hypha. The tube of discharge is very large and broad, usually about equal to the diameter of the sporangium, usually lateral in position. Conidia are rarely as frequent as sporangia, and appear usually lateral. They resemble sporangia in all respects except the mode of germination. Oogonia intercalary or lateral, formed extramatrically, 21μ in transveres diameter and rather more longitudinally. Antheridium generally single and usually arises from the hypha bearing the oogonium, sometimes reduced to a hypogonal cell or a short lateral process arising from a cell cut off immediately below the oogonium; the cell and process together forming the antheridium. Oospores spherical, smooth, average 21μ, extremes 12 to 26μ.

Hab. Saprophytic in garden soil, Antibes, France, Butler.

Pythium monospermum Pringsh., Jahrb. Wiss. Bot. 1: 288. *pl. 21, figs. 2–16.* 1858. Butler, Mem. Dept. Agr. India No. 5, 1: 71–73. *pl. 2, fig. 2.* 1907. (See Butler for synonymy and further references.)

Mycelium forming a cloud around the substratum. Hyphæ irregularly branched, up to 7μ in diameter, often with numerous bud-like outgrowths laterally. Sporangia single or branched, zoospores from a few to 40 or more. Oogonia within and outside the substratum, terminal or intercalary

or formed in the lateral buds. Antheridia one or more, club-shaped, arising from the oogonial or from a distinct hypha. Oospore smooth, completely filling the oogonium, 12–15μ in diameter. Germination takes place after a period of rest.

Hab. Saprophytic in soil, Cork, Great Britain, Butler; on insects in water, Germany, Pringsheim, de Bary; Wahrlich, England, Ward; France, Dangeard.

Species of Ascomycetes

Yeasts. Adametz found a red and a white yeast. These are described extensively by him. Adametz, Leopold. Untersuch. ü. d. niederen Pilze der Ackerkrume. Inaug. Diss., 39–49. 1886.

Saccharomyces glutinus Fres. Adametz, Untersuch. ü. d. niederen Pilze der Ackerkrume. Inaug. Diss. 1886.

On peptone gelatin forms rose-red colonies at 10–12° C. after 9 days, white at 17–18° C. in 4 days; colonies about 0.5 mm. high and 2 mm. in diameter; mostly round, at first having a slimy appearance, later this is lost. No liquefaction of gelatin occurs, grows as well on solid as in fluid media, irrespective of acid or alkaline reaction. Under the microscope the cells are colorless, partly single, partly two or three connected, globose or oval, 3–5μ in diameter, surrounded by a bright membrane; contents granular, sometimes with a central or sometimes with a peripheral vacuole, in which in the greater number of cases the characteristic red shimmer is to be seen without much heating.

In 10 per cent sugar nutrient solution with temperature of 20–25° C. no fermentation is produced even after the course of 3–4 weeks. Reddish sediment is produced. The solution above becomes cloudy. Inverts cane sugar. (Description after Adametz.)

Hab. Isolated from sandy and loamy soil, Germany, Adametz.

Hansenia apiculata Lendner. Kohl, F. G., Die Hefepilze, 273–276. *figs. 36–37.* 1908.

Syn. *Saccharomyces apiculatus* Rees.

Cells usually lemon-shaped. If the nutrimental relations are unfavorable, ovate or elongated cells dominate. Spore formation is unknown. It does not ferment maltose nor invert saccharose. In yeast water with 10 per cent dextrose gives 4.3 per cent alcohol.

Hab. Isolated from soil, Germany, Müller-Thurgau.

Saccharomycopsis capsularis Schönning. Kohl, F. G., Die Hefepilze, 279. *fig. 40.* 1908.

Cells ovate or sausage-shaped. Typical mycelium formation with septa; cardinal points of budding, minimum under 5° C., optimum 25–28° C., maximum 38.2° C. Develops quickly a white, uneven, felt-like mat (kahmhaut) on the culture fluid; on solid media it forms a more or

less uneven white and felty growth; on wort-gelatin it takes on a chocolate-brown coloration after long standing. Characteristic is the velvet-like appearance of the culture on solid media. This is brought about by the numerous hyphæ arising together to form coremia, on whose tips the budding cells become separated.

Spores depressed globose, 3.5–8μ in diameter, mostly four in a cell; with germination the exospore opens with usually two unequally great valves, which remain connected and often remain attached to the spore for a long time. The exospore with sulfuric and several other mineral acids takes on a rose coloration. Cardinal points for sporulation, minimum 5–8° C., optimum 25–28° C., maximum 34.5–35° C. The spores possess a great resistance even against concentrated sulfuric acid. The yeast ferments dextrose, fructose, galactose, and maltose, not, however, saccharose and lactose.

Hab. Found in the soil of a grass field in the northern Alps, Switzerland. Kohl, l. c.

Willia saturnus Klöcker. Kohl, F. G., Die Hefepilze, 285. *fig. 43.* 1908.
Syn. *Saccharomyces saturnus* Klöcker.

Cells globose or ellipsoidal, seldom elongated, mostly 4–6μ long. The rapidly appearing mold membrane (kahmhaut) is white and wrinkled. The temperature limits for budding are, minimum 2–4° C., maximum 35–37° C. Spores are more or less regularly lemon-shaped, with a border from tip to tip, which resembles a picture of Saturn — hence the name *saturnus* — about 3μ long, with a strong refrangible globose body in the center. Cardinal points for sporulation, minimum 4–7° C., optimum on gypsum block 25° C., maximum 28–31° C. Ferments dextrose, fructose, raffinose, and saccharose; does not ferment maltose and lactose.

Hab. Found in the soil of the Himalaya Mountains, also later this species or a very closely related species was found in Denmark and in Italy. Kohl, l. c., 285. No mention is made as to who found the species in the soil.

Willia anomala Hansen. Kohl, F. G., Die Hefepilze, 284. *fig. 42.* 1908.
Syn. *Saccharomyces anomala* Hansen.

Cells small, oval, occasionally elongated, external morphology resembles Torula more than Saccharomyces, vacuolate, with vacuole granules. Nucleus relatively small, 0.8μ. Nuclear membrane visible. In the course of development glycogen vacuoles arise either in the middle of the cell or at each pole. In beer wort, fermentation begins soon after inoculation as well with ordinary temperature as at 25° C. In the beginning of fermentation there is produced a matty gray mold-like membrane (kahmhaut). During fermentation the fluid becomes turbid and a plain odor of fruit ether is manifest. The temperature limits of budding are, 0.5–1° C. minimum, 37–38° C. maximum.

The spores are hat-like, with projecting borders on the edge of the base, diameter without border 2–3μ; spores 2–4 in a mother cell. On germination the spore buds directly. Cardinal points for sporulation on the gypsum block are as follows: minimum 2.5–7.5° C., optimum 30° C., maximum 32–34° C. Spores are found in the mold membrane (kahmhaut) as well as in the sediment.

Hab. Found in impure brewery yeasts in English and Belgium beers, on bran, marsh-mallow sap, in soil, on plums and other fruits.

Chaetomium olivaceum Cooke & Ellis, Grev. 4: 96. 1876. Ellis and Everhart, North American Pyrenomycetes, 124. 1896

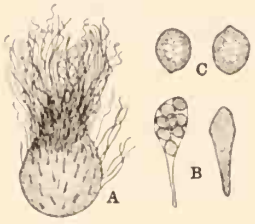

FIG. 111.—*Chaetomium olivaceum Cooke & Ellis.* A, *perithecium, x 60;* B, *mature and immature asci, x 236.6;* C, *ascospores, x 533.3*

Perithecia gregarious, ovate-globose, about 250μ high by 200μ broad, thickly and evenly clothed with soft granular roughened, flexuose, sparingly septate, simple greenish yellow hairs 3–4μ thick, without any very distinct apical tuft of coarser hairs, as is usual in most of the species. Asci oblong clavate p.sp. 35–40 by 12μ. Sporidia crowded, globose, elliptical, apiculate at each end, yellowish brown, 9–12 by 8–9μ (mostly 9–11 by 7–8μ), with one or more guttulæ.

Hab. Isolated from oat field in July, 1910, near the College of Agriculture, Cornell University, Ithaca, N. Y., by the writer. Plant pathology herbarium No. 5,905.

Pleurage verruculosis n. sp.

Perithecia scattered or aggregated, sunken but becoming partly to entirely exposed at maturity, membranaceous to carbonaceous, black, opaque, 350–750 by 225–375μ, pyriform to subglobose, with straight or curved beak.

Asci 4-spored, cylindrical, broadly rounded at apex and tapering below into a slender stipe, perforate, 90–150 by 11–16μ; paraphyses filiform, slightly tapering upward, longer than the asci, septate to articulate.

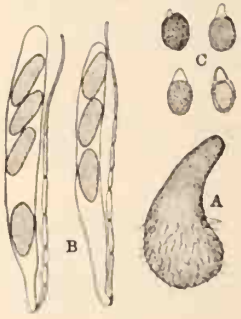

FIG. 112.—*Pleurage verruculosis.* A, *perithecium, x 60;* B, *asci, showing immature spores and paraphyses, x 236.6;* C, *stages in maturation of ascospores, x 236.6*

Spores vertically uniseriate, long ovate when young to subglobose at maturity, obtusely pointed above and broadly rounded to truncate below, germ pore prominent, strongly tuberculate, ranging in color from hyaline when young through brown to black at maturity, 12–14 by 16–18μ, primary appendage 6 to 8μ and conic shortly after migration of protoplasm from below is completed and the septum is formed, at full maturity it

becomes a shrunken hyaline appendage of 3–4μ in length; secondary appendages entirely wanting.

Hab. Soil from oat field July and August, 1910, Cornell University, Ithaca, N. Y., by the writer. Plant pathology herbarium No. 5,906.

Peritheciis sparsis vel gregariis, pyriformis-subglobosis, immersis demum subliberis vel liberis, membranaceis-coriaceis, atris, opacis, ostiolo conico, recto, vel parum curvato; ascis 4-cellularibis, cylindraceis, apice rotundatis, basim versus sensim attenuatis, perforatis, 90–150 x 11–16μ, paraphysibus asceos superantibus, filiformis, sursum attenuatis, articulatis; sporidiis uniseriatis, elongato-ovatis demum subglobosis, 1-nucleatis, tuberculatis, atrofuscis, 12–14 x 16–18μ, caudaque conica saepe curvula hyalina 6–8μ long.

Hab. In campus arabilis, Ithaca, N. Y.

Differs from other species of the genus in the perforate ascus and the lack of secondary appendages. Distinctive characters: 4 spores, perforate ascus; spores tuberculate with primary appendages only.

It is to be observed that this species is placed in the genus Pleurage rather than to form a new genus. This species has been cultivated for over one year on nutrient agar, soil solution agar, and straw plugs, and the above characters are found to be constant.

The formation and development of the spores has been carefully studied. In all cases the primary appendage is formed as given by Griffiths (The North American Sordariaceae, 21. 1901). Iodin and eosin stains have been used to locate secondary appendages in alcoholic and aqueous mounts, but these have never been seen.

Sporormia fasciculata n. sp.

Perithecia scattered or aggregated in small clusters, sunken, with small papilliform beak projecting to the surface, later many become partly exposed, globose, thin membranaceous, inclined to be brittle, black, opaque, 250–525μ in diameter.

Asci 8-spored, broad clavate, broadly rounding above and rapidly contracting just below spores to form a long slender stipe, 45–60 by 16–30μ; stipe about two fifths the length of the ascus; paraphyses absent.

Sporidia fasciculate, straight or very slightly curved, 4-celled, rounded at both ends, deeply constricted and easily separating, 25–30 by 4–7μ, ranging in color from hyaline when young through light brown to dark brown, opaque.

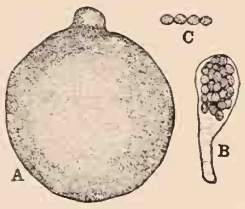

FIG. 113.—*Sporormia fasciculata.* A, *perithecium, x 60;* B, *ascus, showing fasciculate arrangement of ascospores, x 236.6;* C, *ascospores, x 236.6*

Distinctive characters: large perithecia, spores fasciculate, paraphyses wanting.

Hab. Isolated from oat field soil, July, 1910, Cornell University, Ithaca, N. Y., by the writer. Plant pathology herbarium No. 5,907.

Peritheciis sparsis vel caespitosis, immersis, demum saepe subliberis, membranaceo-molliculis, fragilibus, atris, opacis, 250–525μ diameter; ostiolo papillulato, exserto; ascis octosporis, lato-clavatis, apice rotundatis, stipite elongato gracile, 45–60 x 16–30μ; stipite 30–40μ long, sine paraphysibus; sporidiis fasciculatis, rectis vel parum curvatis, 3-septatis, curvulis utrinque, constrictis alte ad septum, facile secedentibus, initio hyalinis, demum atrofuscis, opacis.

Hab. In humis, Ithaca, N. Y., Amer. bor.

Differs from *S. minima* in size and shape of ascus, larger perithecium, and fasciculate spores; from *S. chrysospora* in larger perithecium, in size of ascus, and in smaller spores arranged in fasciculate fashion.

This fungus has been grown continuously for over one year on nutrient agar, soil solution agar, and straw plugs, without variation. Attempts have been made repeatedly to find paraphyses in young material by staining with iodin and eosin. None have been found.

Species of Fungi Imperfecti

Sphaeropsidales

Chaetomella horrida Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 280–281. *pl. 7, fig. 2.* 1902.

Mycelium creeping, from white to darkish, branched, septate; pycnidia 180 by 140μ, superficial, scattered, ovate, without ostiole, brown (Sacc. Chromot. No. 9), in transmitted light dark brown, with setæ on all sides; setæ of the old pycnidia rising high, downward black and opaque, upward lighter, dark or dilute olive, septate, when young smooth, when old slightly roughened, once or many times dichotomously branched, ultimate branches awl-shaped; spores broad elliptical, biconvex, commonly apiculate on both ends, very dilute steel-colored, 5.5–7 by 3.5–4μ; basidia toward the base dark, above hyaline, three times length of spores.

Hab. Isolated from a piece of birch from humous soil of the wood called Spanderswoud, near Bussum, Holland, May 12, 1901, Koning.

Apparently this species is near *Ch. furcata* Cooke & Massee, Grev. **17**: 43. 1888; Sacc. Syll. Fung. **10**: 270. The species differs by its ovoid, brown perithecia, by the apiculate, pale steel-colored, and much smaller spores (5.5–7 by 3.5–4μ as compared with 10–11 by 8μ).

Chaetomella tortilis Delacroix, Bul. Soc. Myc. France **7**: 106. 1891. Sacc. Syll. Fung. **10**: 272. 1891.

Pycnidia without ostioles, nearly semiglobose, gregarious, covered with setæ, 140–160μ in diameter; setæ tortuous, often curved to form hooks,

blunt, smooth, simple, septate, olive-brown, 300–350 by 4.5–5μ; spores partly lemon-like, partly cymbiform, apiculate at both ends, at first pale violet or steel-blue, finally dark violet or black, 10–12 by 6–6.5μ; basidia short, relatively thick, pale brown, either solitary or united in chaplets for the support of the spores.

Hab. Isolated from piece of birch found in the humous soil of the woods called Spanderswoud near Bussum, Holland, May, 1901, Koning.

Sphaeronema Fagi Oud., Arch. Néerl. Sci. Nat. ser. 2, 7: 281. *pl. 9, fig. 1.* 1902.

Pycnidia spherical, loosely surrounded by dark hairs, black, opaque, 92–140μ in diameter, neck hollow, cylindrical, black, opaque, attenuate upward, formed from very thin dark hyphæ 500–540μ high, base 23μ, summit 7.6μ in diameter; glebula of conidia hyaline, elliptical, 3–4 by 2μ. After the liberation of the spores there remain very slender penicillium-like filaments at the summit of the neck.

Hab. Isolated from the decaying leaves of *Fagus sylvatica* from the humous soil of Spanderswoud near Bussum, Holland, May, 1901, Koning.

Hyphomycetes

Mucedinaceae

Sachsia albicans C. Bay, Sachsia ein neues Genus der Hefenähnlichen, nicht Sporentragenden, Pilze. Ber. Deut. Bot. Gesell. 12: 90–93. *fig.* —. 1894.

Colony orbicular, dense, snow-white, raised, margin irregular, deeply crenate; mycelium hyaline, submerged and aerial; submerged mycelium consisting of yeast-like cells usually swollen at both ends, constricted in the middle, occasionally pyriform, guttulate; guttulæ throughout the cell 7–15 by 2–8μ. Aerial hyphæ 26–86μ long by 2–4μ thick, often irregular in diameter, gradually attenuate toward tip, guttulate, with yeast-like cells toward base.

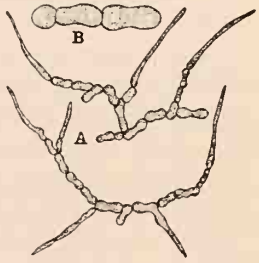

FIG. 114.—*Sachsia albicans C. Bay.* A, *hyphæ, showing method of development and branching, x 236.6;* B, *segments of hypha enlarged, x 533.3*

The original states that the mycelium gives off round, oval, or pyriform spores, similar to Myeoderma but distinguished from this genus in that short mycelial threads arise from the cells or spores. Size of these spores is 0.6–4 by 0.5–3μ. The author further states that he had a culture which produced no spores and no such aggregations as described. Our culture so far has not been observed to produce the spores. The author

gives dimensions of yeast-like cells as 10–20μ long by 2–10μ in diameter, and aerial hyphæ 50–200μ long by 2–10μ wide. Our form, as already observed, does not quite agree with these measurements.

Hab. Isolated from soil of oat field, July, 1910, Cornell University, Ithaca, N. Y., by the writer.

Actinomyces No. 1076b Hagem, Einige Beobachtungen über die Verbreitung der Actinomycetes in der Natur. Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 202. 1910.

Macroscopic appearance, only, is given and is as follows: Grows well at ordinary room temperature. Isolated from same soil and same sample as 1076a. It is distinguished from this by its dark gray colonies, with zonate aerial mycelium that is of a gray-white or frequently reddish white color.

Hab. Isolated from forest soil, Norway, Hagem.

Actinomyces No. 1076a Hagem, Einige Beobachtungen über die Verbreitung der Actinomycetes in der Natur. Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 202. 1910.

Macroscopic appearance, only, is given and is as follows: Thrives rather well on wort-agar and at ordinary room temperature. The colonies are dirty wax-yellow and strongly folded, or plaited. Aerial mycelium does not form.

Hab. Isolated from forest soil, Norway, Hagem.

Actinomyces No. 1075 Hagem, Einige Beobachtungen über die Verbreitung der Actinomycetes in der Natur. Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 202. 1910.

Macroscopic appearance, only, is given and is as follows: Grows very well on wort-agar and only with ordinary temperature relations (ordinary room temperature or up to 20–25° C.). The colonies form great masses of dirty-gray aerial mycelium. Thrives well on filter paper to which has been added ammonium phosphate and inorganic nutrient salts. Digests and uses the cellulose of the filter paper.

Hab. Isolated by A. E. Traaen from mud at the edge of a meadow (Schamm einer Uferweise). Hagem, l. c.

Actinomyces No. 1074 Hagem, Einige Beobachtungen über die Verbreitung der Actinomycetes in der Natur. Vid.-Selsk. Skr. I, Math.-Naturv. Klasse No. 7, 202. 1910.

Macroscopic appearance, only, is given and is as follows: Grows very well on ordinary wort-agar (würzagar). The colonies are somewhat plaited, or folded, and form rich masses of gray-white aerial mycelium. This fungus thrives well at ordinary room temperature, and at blood heat germinates but poorly.

Hab. Isolated twice from forest soil, Norway, Hagem.

Oospora lactis (Fres.) Sacc., Syll. Fung. **4**:15. For synonymy and bibliography see Sacc. Syll. Fung. **20**: 233. 1911. (Compare Lindau, Rab. Krypt. Flora Abt. 8, **1**: 32. 1904–1907.)

Colonies far-spreading, membranaceous, velvety, pure white, often becoming a thick covering over substratum; hyphæ simple or branched, creeping or somewhat ascending, hyaline, of variable length and breadth, mostly 6–12μ broad, breaking up into irregular pieces that are to be considered as spores; spores cylindrical to ovate, often also globose, or somewhat irregular in form, mostly 6–20μ long.

Hab. Isolated from garden soil, Copenhagen, Hansen; Germany, Adametz.

Monilia humicola Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 286. *pl. 20, figs. 1–4.* 1902. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 60. 1904–1907.

Colonies orbicular, dense, at first nearly hyaline, later entirely green; sterile hyphæ creeping, when young hyaline, consisting of alternating longer and shorter cells with granular protoplasm, when old green, consisting of cylindrical cells of equal length with homogenous protoplasm; conidiophores ascending or erect, yellow or green, closely septate, divided into cylindrical articulate cells that readily separate from each other, branched; branches alternate or nearly opposite, once or twice dichotomously divided; conidia in short chains, immature subglobose, mature ellipsoidal, both ends apiculate, greenish, 4–10 by 2–5μ.

Hab. Isolated on gelatin from pulverized humous soil from woods called Spanderswoud near Bussum, Holland, March, 1901, Koning.

Monilia fimicola Cost. et Matr., Rev. Gén. Bot. **6**: 292. *pl. 13, figs. 9–13.* 1894. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 55. 1904–1907.

Colonies far-spreading, powdery, white, occasionally with reddish glimmer, becoming gray with age; hyphæ hyaline, septate, little branched, 2–5μ thick; conidiophore branches 4–5 together, arising from the hyphæ in widely separated groups, irregularly branched, 50–100μ long, sparsely septate, last branches of conidiophores which carry the conidial chains almost constantly about 25μ long, at the tip somewhat attenuated and breaking up into conidial chains; conidia ellipsoidal, both ends somewhat flattened at first, later rounded, hyaline, 6.5–8μ long and 4.5–5.3μ broad.

Hab. On mushroom beds, manure, straw, soil, and the like, in Paris. (Lindau, l. c.) No mention is made as to who found it on soil.

Monilia geophila Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 286. *pl. 19, fig. 1.* 1902. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 56. 1904–1907.

Colonies composed of loosely intertwined hyphæ, yellowish white or ocher-yellow (Sacc. Chromot. 28 and 29); vegetative hyphæ creeping, branched, sparsely septate, fertile hyphæ ascending or erect, closely septate, toward the top either once or twice forked or irregularly branched;

branches few and short; chains of conidia one or two, emerging from the tip of the branch; conidia at first subglobose, afterward elliptical, pale yellow, 3–5 by 2–3μ.

Hab. Isolated on gelatin from pulverized humous soil from woods called Spanderswoud near Bussum, Holland, March, 1901, Koning.

Monilia Koningi Oud., Arch. Néerl. Sci. Nat. ser. 2, 7: 287. *pl. 21, figs. 1–4.* 1902. Lindau, Rab. Krypt. Flora Abt. 8, 1: 59. 1904–1907.

Colonies orbicular, subzonate, brownish rose; vegetative hyphæ hyaline, 4–5μ thick, septate, dichotomously branched; conidiophores racemosely branched; branches basidia-like, 30–40μ long, terminating in single conidial chains; conidia as many as 20 in a chain, subglobose, apiculate at superior end, smooth, 6–8μ in diameter, brownish rose.

Hab. Isolated on gelatin from pulverized humous soil from woods called Spanderswoud near Bussum, Holland, April, 1901, Koning.

Monilia acremonium Delacr., Bul. Soc. Myc. France 13: 114. *pl. 9, fig. C.* 1897. Sacc. Syll. Fung. 14: 1041. 1899. Oudemans, Arch. Néerl. Sci. Nat. ser. 2, 7: 285. *pl. 18, fig. 1.* 1902; Nederl. Kruidk. Arch. ser. 3, 2: 903. 1903. Lindau, Rab. Krypt. Flora Abt. 8, 1: 55. 1904–1907.

Colonies snow-white, slightly floccose; sterile hyphæ creeping, hyaline, sparsely white, with oil drops, 4–5μ thick; conidiophores ascending or erect, ordinarily united in bundles or even twisted, septate, divided above into one or more layers of forked branches, all terminated by chains of numerous conidia; conidia ovate-pyriform, on the base somewhat truncate, at tip ending in a round point, 12–15 by 8–10μ, hyaline.

Hab. On decaying paper in a laboratory in Paris, Delacroix; isolated from humous soil from the woods called Spanderswoud near Bussum, Holland, May, 1901, Koning.

Monilia candida Bonord., Handb. Allg. Myk., 76. *fig.* 86. 1851. Sacc. Fung. Ital. *pl. 851.* 1881; Syll. Fung. 4: 32. 1886. Adametz, Untersuch. ü. d. niederen Pilze der Ackerkrume, 36–39. 1886.

The form of the cells depends on the chemical composition, the reaction, and the state of aggregation of the substratum; for example, on peptone gelatin the fungus produces predominantly long septate hyphæ, while on pieces of apple, yeast cells and short hyphal forms in almost similar amounts arise. Practically, only round yeast cells containing 2–3 vacuoles are produced in 10 per cent cane sugar solution, and these remain connected in chains or clusters. In general, on solid sugar-free and neutral or alkaline nutrient media, the tendency to form long cells predominates, while in fluid, sugar-rich, weak-acid nutrient media, the specific yeast character of round cells is predominant. On gelatin streaks short hyphæ with septa are formed, as well as elliptical to cylindrical cells. The latter are 4–5.5μ broad by 5–10μ long, the former (hyphæ) are of different lengths, with a width of 5–8μ.

In a solution of requisite ash salts plus 0.5 per cent ammonium tartrate and 10 per cent cane sugar, test was made for inversion of the sugar. Inversion took place. The yeast cells forming the membrane in this solution were round, 6–8μ in diameter. Sediment consisted of different-length hyphal forms. (Description after Adametz.)

Hab. Sandy and loamy soil, Germany, Adametz.

Geotrichum candidum Link, Mag. Gesell. Naturf. Fr. Berlin **3**: 17. *pl. 1, fig. 26.* 1809. Sacc. Fung. Ital. *pl. 790.* 1881; Syll. Fung. **4**: 39. 1886. Lindau, Rab. Krypt. Flora Abt. 8, **7**: 76. 1904–1907.

Syn. *Acrosporium candidum* Spreng., Syst. **4**: 556. 1827.
Botrytis geotricha Link, Spec. Plant. **1**: 53. 1824.
Torula geotricha Corda, Sturm D. Fl. Pilze **2**: 73. *pl. 33.* 1828.
Sporotrichum laxum Mart., Fl. Erlang., 335. 1817.

Colonies cushion-like, somewhat powdery, white; hyphæ creeping, sparsely septate; conidiophores erect, short; conidia in chains, short cylindrical, truncate at both ends, 5–10μ long, 4μ broad, hyaline.

Hab. On barren soil, on bones and decaying paper, Germany, Lower Austria, Italy, and France, in summer and autumn. See Lindau, l. c., for statement that fungus grows on barren soil.

Cephalosporium acremonium Corda, Icon. Fung. **3**: 11. *pl. 2, fig. 29.* 1839. Fresenius, Beitr. **3**: 94. *pl. 11, figs. 59–63.* 1863. Sacc. Fung. Ital. *pl. 706.* 1881; Sacc. Syll. Fung. **4**: 56. 1886. Lindau, Verh. Bot. Ver. Brandenb. **45**: 158. 1903; Rab. Krypt. Flora Abt. 8, **1**: 103. 1904–1907. Oudemans, Arch. Néerl. Sci. Nat. ser. 2, **7**: 284. *pl. 15, fig. 1.* 1902.

Colonies orbicular, dense, floccose, at first white, later very light rose-colored; vegetative hyphæ hyaline, sparsely septate, branched, very thin (2.5–3μ thick); conidiophores erect, simple, arising as side branches from vegetative hyphæ, unseptate, 40–60 by 3μ; conidia numerous, elliptical or oblong, straight or curved, nearly hyaline, 4 by 1–1.5μ, borne singly at the apex of the conidiophore, but pressed to the side by the next produced and adhering by means of slime, eventually resulting in a capitule, 14–16μ in diameter and of very dilute rose-color.

Hab. Isolated from humous soil, Holland, Koning.

Cephalosporium humicola Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 285. *pl. 16, fig. 1.* 1902. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 108. 1907.

Colonies orbicular, floccose, at first white, later with white margin and dilute rose-colored center; sterile hyphæ branched, septate, hyaline, 3–5μ thick, intermixed with thicker, irregular segments of septate hyphæ whose cells appear very much as chlamydospores; conidiophores erect, thin, 100–200μ high, unbranched, nonseptate, at the tip with a globose, 20–26μ-in-diameter capitule of a very dilute rose-color; conidia conglutinate, globose, 2.3–2.5μ in diameter, almost hyaline.

Hab. Isolated from pulverized humous soil from the woods called Spanderswoud near Bussum, Holland, March, 1901, Koning.

Cephalosporium Koningi Oud., Arch. Néerl. Sci. Nat. ser. 2, 7: 285. *pl. 17, fig. 1.* 1902. Lindau, Rab. Krypt. Flora Abt. 8, 1: 108. 1904–1907.

Colonies white; sterile hyphæ creeping, branched, hyaline, nonseptate, with intercalary globose or fusiform chlamydospores; chlamydospores with foamy protoplasm, 12–15 by 6–12.5μ; conidiophores erect, continuous, with smoky protoplasm, simple or branched, terminating singly with a globose, 25–35μ-in-diameter glomerule of conidia that adhere closely and are destitute of a membrane; conidia globose, hyaline, continuous, 5–10μ in diameter.

Hab. Isolated on gelatin from humous soil from woods called Spanderswoud near Bussum, Holland, April, 1901, Koning.

Lindau, cited above, is of the opinion that this species belongs with the Mucoraceae on the grounds of the presence of chlamydospores, the lack of septa, and the loose coherence of the spores in the glomerule.

Trichoderma Koningi Oud., Arch. Néerl. Sci. Nat. ser. 2, 7: 291. *pl. 31, figs. 1–7.* 1902. Lindau, Rab. Krypt. Flora Abt. 8, 1: 111. 1907.

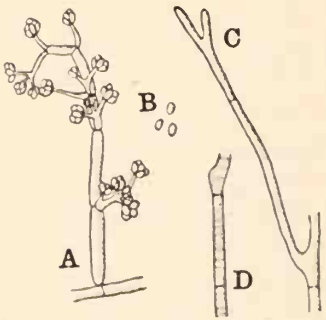

FIG. 115.—*Trichoderma Koningi Oud.* A, *sporangiophore, showing method of branching and conidial heads, x 355;* B, *spores, x 355;* C, *showing method of branching of young hypha, x 355;* D, *showing old vacuolate hypha, x 355*

Colonies orbicular, floccose, at first white, later dotted or spotted with green, finally verdigris or light olive-green; vegetative hyphæ hyaline, very sparsely septate, branched; branches alternate or opposite, each 1- or 2- or 3-forked, ultimate branches carrying the 8–10μ-in-diameter conidial head; conidia almost hyaline, ellipsoidal, 3–4μ long by 2.5–3μ wide, destitute of mucus, soon separating.

Hab. Isolated from humous soil from Spanderswoud near Bussum, Holland, June, 1901, Koning. Isolated repeatedly from soil of plant-breeding plats, Cornell University, Ithaca, N. Y., by the writer. Plant pathology herbarium No. 5,909.

Trichoderma lignorum (Tode) Harz.

Syn. *Pyrenium lignorum α vulgare* Tode, Fungi Mecklenb. 1: 33. *pl. 3, fig. 29.* 1790.

Trichoderma lignorum Harz, Bul. Soc. Imp. Nat. Moscou, 44: 116. *pl. 4, fig. 6.* 1871.

Mucor lignifragus Bul., Champ. *pl. 504, fig. 17.*

Botrytis lignifraga DC., Fl. France 2: 70. 1805.

Trichoderma viride Pers., Tent. Disp. Meth. Fung., 12. 1797.

Trichoderma argenteum Pers., ined. apud Fries Syst. Myc. 3: 215. 1829.

Trichoderma aeruginosum Link, in Mag. Gesell. Naturf. Fr. Berlin 7: 41. 1816.

Trichoderma intermedium Desm., Pl. Crypt. fas. 3: 122.

Sphaeria olivacea Willd., Prodr. Fl. Berol., 416. 1787. Sacc. Syll. Fung. 4: 59. 1886. Lindau, Rab. Krypt. Flora Abt. 8, 1: 110. 1904–1907.

Colonies orbicular, tufted, zonate, at first pure white, then later from the center toward the periphery gradually turning light green, finally becoming darker green, occasionally yellowish green; vegetative hyphæ creeping, hyaline, septate, branched; conidiophores arising as side branches of the mycelium, ascending, nonseptate, di- or trichotomously branched; last branches clavate to lageniform, 8–10 by 2.5μ, supporting the 7–9μ-in-diameter conidial head; conidia light green, globose, 2.5–3μ in diameter.

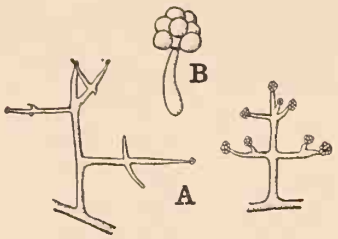

FIG. 116.—*Trichoderma lignorum (Tode) Harz.* A, *sporangiophores, x 355;* B, *part of sporangiophore with conidial head, x 800*

Hab. Isolated constantly from soil about Cornell University, Ithaca, N. Y., by the writer. Plant pathology herbarium No. 5,910.

Corethropsis paradoxa Corda, Prachtflora, 1. *pl. 1.* 1839; Flor. Ill. Muc. Eur., 1. *pl. 1.* 1840. Sacc. Syll. Fung. **4**: 62. 1886. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 118. *figs. 1–3.* 1904–1907.

Syn. *Stachylidium paradoxum* Bonord., Handb. Allg. Myk., 110. *fig. 152.* 1851.

Hyphæ whitish, united to form ascending bundles on base of which grow forth the septate di- or trichotomous conidiophores; conidiophores swollen at the summit, with obclavate sterigmata; conidia ovate, standing singly, hyaline.

Hab. On soil near Prague, Corda.

Aspergillus fumigatus Fres., Beitr. 81. *pl. 10, figs. 1–11.* 1863. Siebenmann, Die Schimmelmykosen, 5. *pl. 1, figs. 3, 4, 6, 7.* 1889. Schroeter, Schles. Krypt. Flora Pilze **2**: 216. Sacc. Syll. Fung. **1**: 65. 1886. Wehmer, Aspergillus, 70. *pl. 1, No. 3; pl. 4, No. 3; pl. 5, fig. 2.* 1901. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 133. *fig. 1.* 1904–1907.

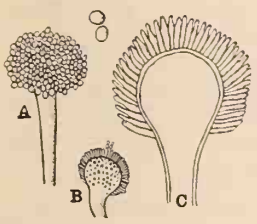

FIG. 117.—*Aspergillus fumigatus Fres.* A, *conidiophore and conidial head, x 236.6;* B, *globose swelling of conidiophore, showing sterigmata, x 236.6;* C, *optical section of globose swelling, x 533.3*

Colonies orbicular, at first light green, finally becoming very dark green; hyphæ creeping, branched, septate, hyaline, 1.5–6μ thick; conidiophores 200–400μ high, 3.5–6μ thick, ascending, erect, hyaline, usually unbranched, uniseptate, toward the summit enlarging into a globose swelling of 10–20μ in diameter; sterigmata cylindrical to clavate, hyaline, 6–8 by 1.5–2μ, simple, continuous; conidia broad ovate to perfectly globose, 2.5–3.5μ in diameter, smooth, catenulate, chains short.

Hab. Isolated from soil of plant-breeding experimental plats, Cornell University, Ithaca, N. Y., frequently, and from roots of pepper and of

corn taken from soil in spring of 1911. Plant pathology herbarium No. 5,911.

Differs from Lindau's description only in slightly smaller heads and shorter (generally) sterigmata.

Aspergillus globosus n. sp.

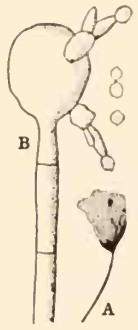

FIG. 118.—*Aspergillus globosus.* A, *conidiophore and conidial fructification, x 60;* B, *globose swelling of conidiophore, showing primary and secondary sterigmata and spores, x 533.3*

Conidiophores singly or aggregated in tufts; tufts olive-green, attaining a maximum height of 0.7 mm., and 0.4 mm. in diameter; conidiophores erect, septate, unbranched, 250–350μ high by 4.5–5.5μ thick, terminating in a subglobose to broad obovate swelling; swelling closely beset with branched sterigmata, 12–20 by 10–15μ; primary sterigmata subglobose to broadly obovate, 5–6 by 4.5–5μ, very easily separating from swelling when placed in mounts; secondary sterigmata 5–8μ long by 1.4–1.6μ broad; conidial head long obovate to cylindrical, 120–225 by 100–190μ; conidia globose, warty, tinged with green, 2–3μ in diameter, in very long chains.

Hab. Isolated from pepper root that was removed from soil from the plant-breeding experimental plats, Cornell University, Ithaca, N. Y., in March, 1911, after having remained in the soil all winter. Description made from fungus growing on sterilized straw plugs. Plant pathology herbarium No. 5,912.

Differs from *A. calyptratus* in the smaller globose swelling, in having branched sterigmata, and in having warty spores.

Conidiophoris solitariis vel cæspitosis; cæspitibus virentibus, maximo 0.7 mm. altitudine, 0.4 mm. diam. Conidiophoris erectis, septatis, simplicibus, 250–350 altitudine x 4.5–5.5μ, apice in vesiculam, subglobosam ad lato-obovatam desinentibus; vesiculis cum sterigmatibus ramosis, 12–20 x 10–15μ; sterigmatibus primariis subglobosis ad lato-obovatis 5–6 x 4.5–5μ, separabilibus facile ab vesiculis; sterigmatibus secundariis 5–8 x 1.4–1.6μ; capitibus conidialibus, longo-obovatis ad cylindricis, 120–225 x 100–190μ; conidiis globosis, tuberculosis, virentibus, 2–3μ diam., longe catenulatis.

Hab. In radicibus hiemantibus Piperacearum. Ithaca, N. Y., Amer. bor.

Differens ab *A. calyptratus* in vesiculis minoribus, sterigmatibus ramosis, et conidiis tuberculosis.

Aspergillus glaucus (L.) Link, Sacc. Syll. Fung. 19: 118–119. 1910. For synonymy and bibliography see Lindau, Rab. Krypt. Flora Abt. 8, 1: 125–127. 1904–1907.

Conidial tufts when young bright green to verdigris green, later becoming darker, and finally becoming gray-green to gray-brown; hyphæ hyaline, often in age yellow to brown, about 3μ thick; conidiophores erect, unbranched, 1–2 mm. high, 14μ or more thick, hyaline, beset with radiating, crowded, simple, short sterigmata that are 10–14μ long by 5–7μ thick; conidia in chains, globose or somewhat ovate, smooth, later mostly fine granular, mostly 7–10μ in diameter, maximum 15μ.

Hab. Isolated from soil, Germany, Adametz.

Aspergillus terricola March, Rev. Myc. **15**: 101. 1893. Sacc. Syll. Fung. **11**: 592. 1895. Wehmer, Aspergillus, 125. 1901. De Wild. et Dur., Prodr. Fl. Belg. **1**: 307. 1898. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 147. 1904–1907.

Sterile hyphæ creeping, hyaline, 2–5μ thick; conidiophores 7–10μ thick; swelling rough, hyaline, 30–50μ in diameter, closely beset with radiating sterigmata 12–15μ long, 4–7μ thick; conidia globose, amber-brown, very fine-spiny, separated by short hyaline isthmuses, in long chains.

Hab. In humous soil near Brussels, Belgium. See Lindau, l. c., for authority that fungus lives in humous soil.

Aspergillus calyptratus Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 283. *pl. 13, fig. 1.* 1902. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 139. 1904–1907.

Vegetative hyphæ hyaline, branched, septate; fertile hyphæ 200–300μ high, strict or subflexuose, continuous, toward base hyaline, toward top dilute green, ending in an ellipsoidal or obpyriform swelling, 20–22μ in diameter, concolorous; sterigmata very close, very numerous, cylindrical, acute, 6μ long; conidia perfectly globose, smooth, grayish, 2.3μ in diameter, in series of very long chains, which form a dark cylindrical body up to 170μ high.

Hab. Isolated from a decaying piece of oak from humous soil from Spanderswoud near Bussum, Holland, May, 1901, Koning.

Aspergillus Koningi Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 284. *pl. 14, fig. 1.* 1902; Nederl. Kruidk. Arch. ser. 3, **2**: 899. 1903. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 147. 1907.

Colonies cream-colored (Sacc. Chromot. No. 27); vegetative hyphæ creeping, branched, septate, hyaline; conidiophores strict or curved, simple, nonseptate, hyaline, up to 400μ high, apex swollen to form a subglobose, smooth, hyaline sphere of 16–20μ in diameter; conidial head globose, up to 135μ in diameter; sterigmata narrow clavate, hyaline, rounding at tip, simple, nonseptate, 8–10 by 2.5μ; conidia globose, cream-colored, 3μ in diameter, smooth, catenulate.

Hab. Isolated on gelatin media from humous soil from Spanderswoud near Bussum, Holland, June, 1901, Koning. Isolated from experimental plats of Plant-Breeding Department, Cornell University,

Ithaca, N. Y., September and December, 1910, and January, 1911. Plant pathology herbarium No. 5,913.

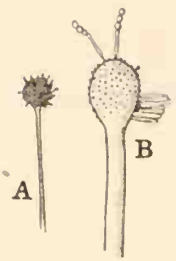

FIG. 119.—*Aspergillus Koninvi Oud.* A, *conidiophore and conidial head, x 90;* B, *globose swelling of conidiophore, showing sterigmata and spores, x 355*

The original gives the conidial head as being only 85μ in diameter. It is not uncommon to find it measuring 130μ in diameter. Also, the conidiophores measure as high as 400μ. The original gives the mycelium as continuous, while it is sparsely septate.

Penicillium chrysogenum Thom, Cultural Studies of Species of Penicillium. U. S. Dept. Agr., Bur. Anim. Indus. Bul. 118: 58–60. *fig. 20.* 1910.

Cultivated in 15 per cent gelatin in distilled water, 15 per cent gelatin plus 3 per cent cane sugar in distilled water, potato decoction plus 1.5 per cent agar, potato decoction plus 3 per cent cane sugar plus 1 per cent agar, at first blue-green, becoming with age slate-gray in agar and gelatin without cane sugar, where sugar is added to gelatin or agar the colonies do not become as gray as where sugar is omitted, broadly spreading in the substratum with a wide sterile white margin when young. Reverse of colony yellow-green. Conidiophores mostly arising separately, 100–250μ high by 3–5μ thick, with 1–3 alternate diverging branches bearing once or twice verticillate branchlets. Conidiiferous cells 7–10 by 2–3μ, usually in verticils; conidia globose, 3–5.5μ in diameter. Colonies liquefy gelatin with alkaline reaction to litmus, and in gelatin and on potato plugs a lemon-yellow color.

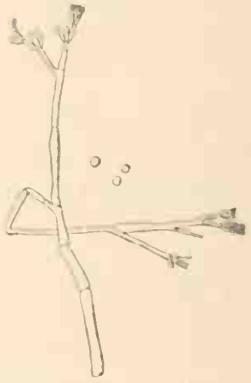

FIG. 120.—*Penicillium chrysogenum Thom. Conidiophore, showing conidial fructification, x 236.6; spores, x 533.3*

Hab. Isolated from soil of oat field, Cornell University, Ithaca, N. Y., July and August, 1910, by the writer.

Writer's culture data:

Color.— Blue-green to slate-gray when old; reverse light yellowish green. In some media lemon-yellow; in others, none.

Odor.— None.

Fifteen per cent gelatin in water, good growth, lemon-yellow color in gelatin, liquefaction rapid, 6–10 days, more or less rapid and complete in all gelatin media used, litmus reaction alkaline. Potato agar, good growth, no yellow color. Potato plugs, good growth, potatoes become yellow. Raulin's fluid, good growth, with age the under surface of mat near test tube assumes a purplish tint, no yellow in fluid. Cohn's solution,

not as good growth as in Raulin's fluid, solution becomes yellow. Lactose 3 per cent, slight growth, no coloration of media. Lactic acid 9 per cent, very slight growth. Glycerin 3 per cent, fair growth, no coloration in fluid.

Penicillium geophilum Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 288. *pl. 25, figs. 1–5.* 1902; Nederl. Kruidk. Arch. ser. 3, **2**: 907. 1903. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 161. 1904–1907.

Colonies orbicular, zonate; zones at first alternating light and dark green, later changing to white and bright green; vegetative hyphæ creeping, branched, septate, hyaline, 4–8μ thick; conidiophores erect, to 360μ high by 6μ thick, hyaline, remotely septate, at the summit with a verticil of usually 9 branches; branches lageniform, swollen at the tip, occasionally curved, 30μ long, carrying very long conidial chains; conidia globose, bright green but appearing almost hyaline, smooth, 3–4μ in diameter.

Hab. Humous soil from woods called Spanderswoud near Bussum, Holland, March, 1901, Koning.

Penicillium desciscens Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 288. *pl. 24, figs. 1–5.* 1902; Nederl. Kruidk. Arch. ser. 3, **2**: 907. 1903. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 162. 1904–1907.

Colonies green-gray to blue-green, becoming zonate with age; mycelium branched, septate, hyaline, with age becoming guttulate, 2–4μ thick; conidiophores 80–500μ high, hyaline, septate, generally with one or two side branches, with four to six 9–12μ-long primary branches at the apex; each primary branch producing 4–6 basidia, which are 6–9μ long; conidia ellipsoidal to globose, persisting in long chains in liquid mounts, 2.5–3.5μ in diameter.

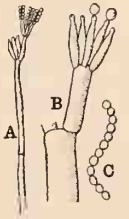

FIG. 121.—*Penicillium desciscens Oud.* A, *conidiophore and conidial fructification, x 60;* B, *part of conidial fructification, x 533.3;* C, *spores, x 533.3*

Hab. Isolated from humous soil from Spanderswoud near Bussum, Holland, March, 1901, Koning; from oat field near Cornell University, Ithaca, N. Y., July and August, 1910, by the writer.

While the fungus does not agree in all particulars with the original description of Oudemans, still in all probability our form is identical with his.

Writer's culture data. Cultures retained for 30 days:

On 15 per cent gelatin in distilled water, and on potato decoction plus 1.5 per cent agar, colonies when young green-gray becoming brownish and zonate with age. Reverse of colonies yellowish green on 15 per cent gelatin in distilled water plus 3 per cent cane sugar and on potato decoction plus 3 per cent cane sugar, plus 1 per cent agar, at first the colonies are blue-green, fading somewhat with age. Reverse of colonies yellowish green to red. Odor none.

Glycerin 3 per cent, slight growth but no fruit. Potato plugs, good growth, blue-green when young becoming gray-green above and with age assumes an orange-yellow coloration on the under surface of the mat. Lactose 3 per cent, same as with glycerine, slight floccose growth throughout medium. Raulin's fluid, very heavy wrinkled mat that is pink at first before fruiting to any extent, during latter half of cultural period the fluid becomes deep wine-red. Cohn's solution, gray when young, after 10 days mat becomes pink beneath, growth less than in Raulin's. Lactic acid 0.9 per cent, slight growth.

Penicillium silvaticum Oud., Arch. Néerl. Sci. Nat. ser. 2, 7: 289. *pl. 27, figs. 1–4.* 1902; Nederl. Kruidk. Arch. ser. 3, 2: 908. 1903. Lindau, Rab. Krypt. Flora Abt. 8, 1: 167. 1904–1907.

Colonies orbicular, light brown, nonzonate; vegetative hyphæ creeping, branched, septate, hyaline, 1.3–6.6μ thick; conidiophores erect, to 210μ high, 2–3.3μ thick, hyaline, septate, with a verticil of 5–8 branches on the summit; branches lageniform, inflated at the tip, 16–22μ long; conidia emerging from the apex of the branch in very long (100–160μ) chains, globose, light brown, smooth, 2–3μ in diameter.

Hab. Isolated from humous soil from woods called Spanderswoud near Bussum, Holland, March, 1901, Koning.

Penicillium terrestre n. sp.

Colonies round, yellowish green; sterile hyphæ branched, septate, hyaline, 2–6μ thick; conidiophores 70–375μ high, 2–4μ thick, hyaline, septate, toward the top with one or two primary side branches or bearing simply a verticil of usually 3 primary branches; primary side branches each have at the summit a verticil of 2–5 basidia, or occasionally the primary side branch may bear a secondary branch, both primary and secondary then bearing at their summits 2–5 basidia in a verticil; when only a verticil of primary branches is borne on the summit, each bears 2–5 basidia; branches of the verticil 10–15μ long, cylindrical; basidia 7–11μ long, lageniform; conidia hyaline, globose, 2–3μ in diameter, borne in long chains.

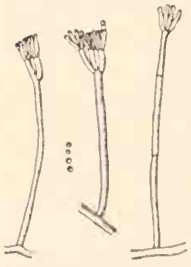

FIG. 122.—*Penicillium terrestre. Conidiophores and conidial fructification, x 236.6*

Hab. Soil of plant-breeding plats, Cornell University, Ithaca, N. Y. Isolated very frequently during winter and spring, 1910–1911, by the writer. Plant pathology herbarium No. 5,916.

Coloniis rotundis, luteo-viridibus; hyphis sterilibus ramosis, septatis, hyalinis, 2–6μ diam.; conidiophoris 70–375μ altitudine, 2–4μ diam., hyalinis, septatis, versus apicem 1–2 ramosis vel solum verticillatim ramos (plerumque tres) ferentibus, ramosis primariis singulis apice 2–5 basidia verti-

cillatim ferentibus, vel interdum ramis primariis ramum secondarium ferentibus, tum ramis secondariis apice 2–5 basidia verticillatim ferentibus; cum solum rami primarii apice verticillatim feruntur, uterque 2–5 basidia fert; ramis secundarius cylindricis, 10–15μ longitudine; basidiis 7–11μ longitudine, lageniformis; conidiis hyalinis, globosis, 2–3μ diam., longe catenulatis.

Hab. In humis, Ithaca, N. Y., Amer. bor.

Penicillium humicola (Oud.) emend. Arch. Néerl. Sci. Nat. ser. 2, **7**: 290. 1902.

Colonies round, at first yellowish green in center, finally dark green, surrounded by yellow margin, which fades into white. Reverse of colony in media containing sugar, red; sterile hyphæ branched, septate, yellowish green, 1–4μ thick; conidiophores 110–200μ high, 1–3.2μ thick, hyaline, septate, either 3 verticillate primary, 8–10μ-long, branches at tip, which produce at their tips 3 secondary branches 5–13μ long, or varying from this to 3 primary branches, the side branches of which may produce 3 or 4 secondary branches, the center sometimes being dichotomous, the dichotomous branches produce at their tips 3 or 4 secondary branches, secondary branches flask-shaped; conidia yellowish green, globose, 2–4.5μ in diameter, in short chains.

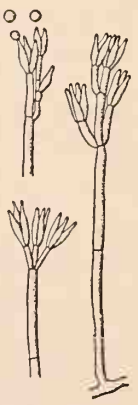

FIG. 123.—*Penicillium humicola* (Oud.) emend. *Conidiophores and conidial fructification, x 400*

This form varies from *P. humicola* in being larger in form, with less regularity in conidial fructification, and not having primary branches S-shaped or curved.

Hab. Isolated constantly from Dunkirk clay loam near College of Agriculture in plant-breeding grounds, Cornell University, Ithaca, N. Y., by the writer.

Penicillium expansum (Link) Thom, Cultural Studies of Species of Penicillium. U. S. Dept. Agr., Bur. Anim. Indus. Bul. 118: 27–29. *fig. 1.* 1910.

Syn. *Coremium glaucum* Link, Observations, 19. Icones **5**, *fig. 31.* 1809.
Floccaria glauca Grev., Scottish Flora. *pl. 301, figs. 1–4.*
Penicillium glaucum Link (in part), Spec. Plant. **6**: 70. 1824.
Coremium vulgare Corda (in part), Prachtflora, 54. *pl. 25, especially figs. 3, 4, 17, 18, 19, 20, and 21.*
Possibly *Penicillium elongatum* Dierckx.

Colonies on gelatin and potato agar green, becoming gray-green and slowly brown in several weeks (especially when exposed to light), floccose, with concentric zones tufted with short, loose, coremium-like aggregations of conidiophores, not over 1–2 mm. in height except in old cultures containing sugar, broadly spreading, with broad white margin in growing colonies. Reverse somewhat yellowish brown; conidiophores either very short lateral branches of aerial hyphæ, or very long (1 mm. or more),

arising singly or grouped with others to form coremia. Conidial fructification consists of the three main branches bearing verticils of branchlets supporting crowded whorls of conidiiferous cells 130–200 by 50–60μ at base in cultures without sugar, with sugar continuing for some weeks to produce a great number of conidia that come to form masses perhaps 1 mm. in thickness; conidiiferous cells 8–10 by 2–3μ; conidia elliptical to globose, 2 by 3.3μ or 3–3.4μ, green, homogenous, persisting in chains when mounted. Colonies begin to liquefy gelatin by sixth day.

FIG. 124. — *Penicillium expansum (Link) Thom. Conidiophores and conidial fructification, x 236.6*

Hab. Isolated quite generally from soil by the writer; from sandy and loamy soil, Germany, Adametz.

Amblyosporium echinulatum Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 282. *pl. 11, fig. 1.* 1902; Nederl. Kruidk. Arch. ser. 3, **2**: 759. 1902. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 179. 1904–1907.

Colonies orbicular, gray-green; vegetative hyphæ hyaline, articulate, branched; fertile hyphæ swollen at tip, up to 200μ high, toward base hyaline, toward top with dilute gray-green branches; branches basidia-like, closely and repeatedly verticillate or spirally arranged, lageniform, continuous, 25μ high; conidia catenulate, at first hyaline and globose, afterward dilute gray-green and ovoid or broad elliptical, truncate at ends, with an apiculus, very minutely spiny, continuous, 8–12 by 6–9μ.

Hab. Isolated from pulverized humous soil from forest called Spanderswoud near Bussum, Holland, June, 1901, Koning.

Monosporium acuminatum var. **terrestre** Sacc., Fung. Ital. *pl. 868.* 1881; Syll. Fung. **4**: 114. 1886. Lindau, Rab. Krypt. Flora Abt 8, **1**: 264. *figs. 1–3* on *p. 262.* 1904–1907.

Colonies spreading, thin, white; conidiophores erect, sparsely septate, dendroidly branched; branches ascending, simple or branched, acute; conidia hyaline, oblong, acrogenous, 5–6 by 3μ.

Hab. On humous soil in Venice in September, Saccardo.

Monosporium silvaticum Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 287. *pl. 22, figs. 1–3.* 1902; Nederl. Kruidk. Arch. ser. 3, **2**: 905. 1903. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 266. 1904–1907.

Colonies orbicular, white; vegetative hyphæ creeping, branched, continuous, hyaline; conidiophores erect, continuous, hyaline, dendroidly branched, with ultimate branches commonly two- rarely three-forked; conidia singly acrogenous at the apices of the branches, hyaline, obovate, 3 by 2μ.

Hab. Isolated from pulverized humous soil from woods called Spanderswoud near Bussum, Holland. June, 1901, Koning.

Botrytis fulva Link, Spec. Plant. 1: 58. 1824. Sacc. Fung. Ital. *pl. 696.* 1881; Syll. Fung. 4: 123. 1886. Lindau, Rab. Krypt. Flora Abt. 8, 1: 280. 1904–1907.

Syn. *Sporotrichum fulvum* Fries, Syst. Myc. 3: 418. 1832.
Polyactis fulva Bonord., Handb. Allg. Myk., 115. *figs. 128–159.* 1851.
Dematium ollare Pers., Syn., 697. 1801.

Colonies in form of a stratum, rather thick, spreading, yellow-brown, consisting of thickly intertwined or cobwebby hyphæ; conidiophores much branched; conidia globose, 4–5.5μ in diameter, with fine spines, yellow-brown.

Hab. On moist earth, decaying sorghum culms, on stalks of *Allium cepa*, decaying branches of *Salix pentandra* and other broad-leaved woods, stumps, and so forth, in Germany, Poland, Italy, and France, in summer and autumn. See Lindau, l. c., for statement that this species grows on moist soil.

Botrytis dichotoma Corda, Icon. Fung. 1: 18. *fig. 244.* 1837. Sacc. Syll. Fung. 14: 123. 1886. De Wild. et Dur., Prodr. Fl. Belg. 2: 312. 1898. Cavara, Atti Ist. Bot. Univ. Pavia 3: 343. *pl. 26, figs. 20–23.* Lindau, Rab. Krypt. Flora Abt. 8, 1: 281. 1904–1907.

Syn. *Campsotrichum dichotomum* Bonord., Handb. Allg. Myk., 102. 1851.

Colonies small, white with cinnamon-colored spots; conidiophores erect, closely forked, extreme branches blunt and slightly curved inward, hyaline, 12–14μ thick; conidia produced in great numbers in the form of a spiral, globose, often angled from lateral pressure, yellow-cinnamon brown.

Hab. On decaying leaves and moist earth in Bohemia, Corda; near Pavia, Cavara; and in Belgium. See Lindau, l. c., for authority that fungus grows on moist soil.

Botrytis geophila Bonord.

Syn. *Polyactis geophila* Bonord., Handb. Allg. Myk., 115. *fig. 163.* 1851.
Botrytis geophila Sacc., Syll. Fung. 4: 125. 1886. Lindau, Rab. Krypt. Flora Abt. 8, 1: 282. 1904–1907.

Colonies gray, delicate; conidiophores short, septate, almost hyaline, upward dichotomously branched, with short, blunt, forked end branches that appear as crutches; conidia small, globose, blackish.

Hab. On moist soil in fir woods in Westphalia, Bonorden.

Botrytis terrestris n. sp.

Colonies at first white, later gray; sterile hyphæ creeping, hyaline, branched, septate, 1.5–3μ in diameter; conidiophores erect, ascending, septate, branched, 2–3.5μ in diameter, 50–200μ high; primary and secondary branches verticillate, dichotomous, or alternate; conidia produced on the ends of the branches, forming more or less compact triangular clusters that average 20–25μ, obovate, somewhat angled, uniform 2.5–3 by 3–4μ, hyaline to light gray. Clusters of conidia separate very easily.

Hab. Isolated from potato soil on experimental plats at North Cohocton, N. Y., by the writer, May, 1911, and grown on soil solution agar, nutrient agar, and straw plugs. Plant pathology herbarium No. 5,919.

Coloniis initio albis, deinde griseis; hyphis sterilibus repentibus, hyalinis, ramosis, septatis, 1.5–3μ diam.; conidiophoris erectis v. assurgentibus, septatis, ramosis, 2–3.5μ diam., 50–200μ altitudine; ramis primariis et secundariis verticillatis, facientibus cæspites densiores, confertiores et triangulos, 20–25μ, obovatis, aequabiles 2.5–3 x 3–4μ, hyalinos v. griseos. Cæspitibus conidialibus facile separabilibus.

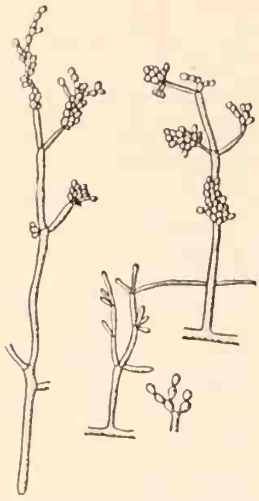

FIG. 125.—*Botrytis terrestris. Conidiophores and conidial clusters, x 355*

Hab. In humis, North Cohocton, N. Y., Amer. bor.

Botrytis cinerea Pers., Tent. Disp. Meth. Fung., 46. *pl.* 3, *fig.* 10. 1797; Syn., 690. 1801. Link, Spec. Plant. 1: 60. 1824. Fries, Syst. Myc. 3: 396. 1832. Sacc. Syll. Fung. 4: 129. 1886. De Wild. et Dur., Prodr. Fl. Belg. 2: 312. 1898. Wehmer, Beitr. Kenntn. einh. Pilze, 2: 81. *pl.* 3, *figs.* 12–14. 1895. Lindau, Verh. Bot. Ver. Brandenb. 47: 64. 1905; Rab. Krypt. Flora Abt. 8, 1: 284–290. 1904–1907.

See Lindau, l. c., for synonyms and further bibliography.

Colonies diffuse, gray, gray-green, dark olive-green to brown-black, seldom brown or reddish green, dusted gray from the conidia, loose or dense, up to 2 mm. high; conidiophores erect, unbranched or seldom branched, septate, 11–23μ thick, with blackish brown membrane, toward the summit almost hyaline, at the summit with several (3 and more) somewhat half-globose outgrowths (auswüchsen) from which the conidia are formed singly on very fine wart-like projections. The tip of the conidiophore grows between the outgrowths (warzen), whereby they become separated and placed laterally, occasionally in this position they still carry single conidia. The conidia stand so thickly on the projections (auswüchsen) that thick heads are produced which soon fall off, ovate or elliptical to almost globose, on the base finely apiculate, 9–12 (up to 15)μ long and 6.5–10μ broad, with almost hyaline, hardly brownish membrane.

Hab. Cosmopolitan; on living, dying, or dead plant members; isolated from soil, Switzerland, Lendner.

Botrytis epigaea Link, Spec. Plant. 1: 53. 1824. Oudemans, Nederl. Kruidk. Arch. ser. 4, 2: 248. 1884. Sacc. Syll. Fung. 4: 136. 1886. Lindau, Verh. Bot. Ver. Brandenb. 47: 65. 1905; Rab. Krypt. Flora Abt. 8, 1: 299. 1904–1907.

Syn. *Polyactis epigaea* Bonord., Handb. Allg. Myk., 115. *fig.* 161. 1851.

Colonies far-spreading, floccose, at first white, then yellowish-brown to red-brown; hyphæ creeping, septate, 11–16μ thick, with brownish,

thin, granulated membrane. From the principal hyphæ are produced side branches that average 30–40μ long; side branches are mostly without septa, with smooth, bright membrane, on the summit irregularly and slightly swollen and ending in a great number of wholly irregular, thin, 5–7μ-long, hyaline projections (zähnen). The principal stem rarely ends similar to the side branches; conidia borne singly on the projections, globose, 3.5–5.5μ in diameter, hyaline, uniguttulate.

Hab. On barren sandy soil in woods in Germany, Holland, Italy, France, and North America, in summer and autumn.

var. **rosea** Sacc., Fung. Ital. *pl. 689.* 1881; Syll. Fung. **4**: 136. 1886. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 300. 1904–1907.

Syn. *Hyphelia terrestris* Fries, Syst. **3**: 213. 1829.
Trichoderma tuberculatum Pers., Obs. Myc. **1**: 12. *pl. 2, fig. 8.* 1796.
Trichoderma nemorosum Pers., Traite Champ. Comest. 1818. (cfr. Fries, l. c.)
Trichoderma laeve Schumach., Saell. **2**: 236. 1803.
Trichoderma varium Ehren., Sylv. Myc. Berol., 11. 1818.

Colonies reddish; conidiophores standing compact, septate, branched or forked, clavate on the summit; conidia globose, 3μ in diameter, borne on the points of the clavate branches.

Hab. On soil in Germany, Austria, North Italy, Finland, and Siberia, summer and autumn. Lindau, l.c.

Lindau considers this variety as superfluous because of the great variation of the species.

Botrytis purpureospadicea (Fuckel) Lindau.

Syn. *Hyphelia purpureospadicea* Fuckel, Symb., 363. 1869.
Botrytis purpureospadicea Sacc., Syll. Fung. **4**: 121. 1886. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 305. 1904–1907.

Colonies floccose, up to 5 cm. in diameter, brown-purple; conidiophores branched, 10–13μ thick, nonseptate, finally falling and disappearing; conidia globose, dirty-rose, 5μ in diameter, guttulate.

Hab. On sandy soil between grass near Bundenheim in the Rhine Province (Rheingau), Fuckel.

Lindau considers this an insufficiently known species.

Verticillium terrestre (Link) Lindau.

Syn. *Stachylidium terrestre* Link, Mag. Gesell. Naturf. Fr. Berlin **3**: 15. *fig. 21.* 1809; Spec. Plant. **1**: 78. 1824. Greville, Scot. Crypt. Fl. *pl. 257.* 1827. Chevallier, Fl. Gén. env. Paris, **1**: 70. *pl. 4, fig. 14.* 1826. Fries, Syst. Myc. **3**: 391. 1829.
Botrytis terrestris Pers., Myc. Eur. **1**: 38. 1822. Bomm. et Rouss., Fl. Myc. env. Brux., 274. 1884. Lambotte, Fl. Myc. Belg. **3**: 230. 1880.
Stachylidium candidum Grev., in Werner Trans. **4**: 72. *pl. 5, fig. 2.* 1822.
Verticillium terrestre Sacc., Syll. Fung. **4**: 152. 1886. De Wild. et Dur., Prodr. Fl. Belg. **2**: 316. 1898. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 320. 1904–1907.

Colonies white, consisting of thick, cobwebby, branched hyphæ; conidiophores erect, septate, upward with four associated branch whorls;

branches short-blunt, rarely again verticillately branched; conidia globose, soon falling.

Hab. On barren soil and surrounding pieces of wood in Germany, Belgium, England, and Sweden. Lindau, l. c.

Acrostalagmus albus Preuss. var. **varius** n. var.

Colonies effused, thin, subfloccose, white; vegetative hyphæ hyaline, branched, septate, 2–3.5μ; conidiophores creeping, ascending, or erect, branched, 15–75μ high, 2–3.5μ thick; branches continuous, usually simple but occasionally ternately branched, verticillate, alternate toward apex, slightly curved, at the summit producing a cap or head of conidia, 15–36 by 2–3μ; verticils very frequently but 1, never more than 3; cap globose, 3–12μ; conidia hyaline, oblong, variable in size, 2.8–9 by 1–4μ mostly 3.3 by 1.5μ.

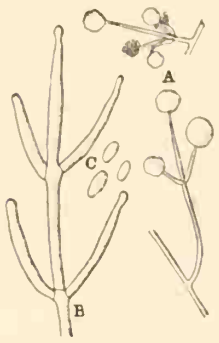

FIG. 126.—*Acrostalagmus albus Preuss. var. varius.* A, *conidiophores and conidial heads, x 236.6;* B, *same enlarged, x 533.3;* C, *spores, x 533.3*

Hab. Isolated from soil of plant-breeding plats, Cornell University, Ithaca, N. Y., and from potato tuber, March, 1911. Plant pathology herbarium No. 5,920.

Varies from type in the shorter conidiophores, fewer verticils, branches being occasionally branched, greater variation in size of cap of conidia and of conidia.

Ascrostalagmus cinnabarinus var. **nana** Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 282. *pl. 10, fig. 1.* 1902.

Colonies orbicular, orange (Sacc. Chromot. No. 21) mixed with red; vegetative hyphæ branched, septate; fertile hyphæ septate, with 2 or 3 series of opposite unicellular branches; branches terminated by 3-rayed verticils, with each ray in the form of a ninepin (36–45μ long) and serving as the support of a glomerule of conidia; conidia ellipsoidal or oblong, rounding at both ends, 5–8 by 3–5μ, united by a gelatinous liquid. All parts of the plant are tinted with excessively weak rose.

Hab. Isolated from pulverized humous soil from Spanderswoud near Bussum, Holland, September, 1901, Koning.

The variety differs from the type in its smaller dimensions, its unicellular, opposite, nonverticillate branches, which are divided into 3 instead of 4 rays. Its conidia, on the contrary, are much larger (5–8 by 3–5μ as against 3–4 by 1.5μ).

Spicaria silvatica Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 291. *pl. 30, figs. 1–4.* 1902; Nederl. Kruidk. Arch. ser. 3, **2**: 910. 1903. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 353. 1904–1907.

Colonies orbicular, light gray-green; vegetative hyphæ creeping, hyaline, septate, with forked branching, 2–6μ thick; conidiophores erect, 2–3μ thick, sparsely branched, with branches alternate; branches of different lengths, simple or forked at the tip with 3 verticillately placed, cylindrical, nonseptate, somewhat curving, 20–25μ-long branchlets; conidia in long chains, ellipsoidal or oblong, 6–12 by 4–6μ, hyaline, smooth.

Hab. Isolated from humous soil from woods called Spanderswoud near Bussum, Holland, June, 1901, Koning.

Spicaria decumbens Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 290. *pl. 28, figs. 1–2.* 1902. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 353. 1907.

Colonies hyaline; vegetative hyphæ decumbent, septate, closely racemosely branched; conidiophores ascending, septate, simple or branched; branches opposite or alternate, mostly simple; occasionally toward the tips producing short septate branches; end branches 2–5, verticillate, lageniform, 12–16μ long, resembling sterigmata; conidia in long chains, ellipsoidal, hyaline, 3–4μ in diameter.

Hab. Isolated from humous soil from wood called Spanderswoud near Bussum, Holland, June, 1901, Koning.

Spicaria elegans (Corda) Harz.

Syn. *Penicillium elegans* Corda, Icon. Fung. **2**: 18. *fig. 74.* 1838.
Hormodendrum elegans Bonord., Handb. Allg. Myk., 77. 1851.
Spicaria elegans Harz, Bul. Soc. Imp. Nat. Moscou **44**: 138. 1871. Sacc. Fung. Ital. *pl. 895.* 1881; Syll. Fung. **4**: 166. 1886. Oudemans, Arch. Néerl. Sci. Nat. ser. 2, **7**: 290. *pl. 29, figs. 1–2.* 1902; Nederl. Kruidk. Arch. ser. 3, **2**: 909. 1903. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 350. 1904–1907.

Colonies somewhat spreading, white, velvety; vegetative hyphæ creeping, hyaline, septate; conidiophores erect, septate, with 2–4 circles of opposite or 3–4 verticillate branches; branches short, fusiform, each divided at the tip into a verticil of 3 branchlets; branchlets lageniform, swollen at the tip; conidia ovate-fusiform, united to form long chains, 4–5 by 3.5–4μ, hyaline.

Hab. On the inside of decaying fir bark in Bohemia, Corda; on decaying willow branches in Vienna woods, von Höhnel; on a piece of decaying wood in humous soil near Bussum, Holland, Koning; on wood and bark in England; on decaying Fistulina in Venice, Saccardo; in summer and autumn.

Spicaria simplicissima Oud., Nederl. Kruidk. Arch. ser. 3, **2**: 763. 1903. Lindau, Rab. Krypt. Flora Abt 8, **1**: 353. 1907.

Colonies orbicular, with alternating zones of cream-yellow and dirty gray, occasionally zones show tinge of violet; vegetative hyphæ creeping, very thin, septate, hyaline, dichotomously branched; conidiophores erect, 40μ high, septate, hyaline, usually unbranched, at the most with a small side branch, on the tip constantly producing three branchlets; branchlets nonseptate, 8–12μ long, verticillate; conidia 2–3μ, in short chains, globose.

Hab. Isolated from humous soil from Bussum, Holland, September, 1903, Koning; from soil of plant-breeding plats, Cornell University, Ithaca, N. Y., in November, 1910, and January, 1911, also from potato tubers. Plant pathology herbarium No. 5,921.

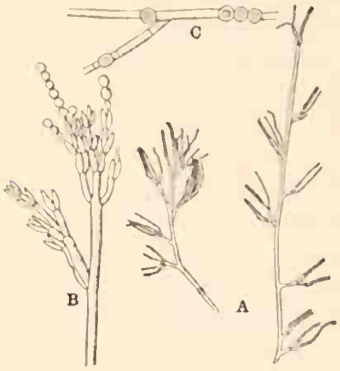

FIG. 127.—*Spicaria simplicissima Oud. A, conidiophores and conidial fructification, x 236.6; B, same enlarged, x 533.3; C, chlamydospores, x 533.3*

Naematogonium humicola Oud., Arch. Néerl. Sci. Nat. ser. 2, 7: 288. *pl. 23, figs. 1–3.* 1902. Nederl. Kruidk. Arch. ser. 3, 2: 905. 1903. Lindau, Rab. Krypt. Flora Abt. 8, 1: 360. 1907.

Colonies orbicular, velvety, at first white, later light green, finally cream-colored (Sacc. Chromot. No. 27); conidiophores ascending, 2.2–3.3μ thick, hyaline, septate, unbranched, consisting of perfectly cylindrical long cells alternating with swollen, shorter, fertile cells; conidia sessile, globose, 3–4μ in diameter, or ellipsoidal 3–6 by 2–4μ, almost hyaline.

Hab. Isolated from pulverized humous soil from woods called Spanderswoud near Bussum, Holland, June, 1901, Koning.

Trichothecium roseum Link, Mag. Gesell. Naturf. Fr. Berlin 3: 18. *fig. 27.* 1809.

Syn. *Puccinia rosea* Corda, Icon. Fung. 1: 6. *fig. 98.* 1837.
Dactylium roseum Berk. Lambotte, Fl. Myc. Belg. 3: 244. 1880.
Cephalothecium roseum Corda, Icon. Fung. 2: 14. *fig. 62.* 1838.
Cephalothecium candidum Bonord., Handb. Allg. Myk., 81. *fig. 89.* 1851

Colonies forming a powdery or velvety covering, wide-spreading, mold-like or cobwebby, at first white, later rose-red; vegetative hyphæ septate, branched, 1.5–6μ; conidiophores erect, sparsely or nonseptate, mostly unbranched, 200–500 by 3–3.5μ; conidia acrogenous, produced singly one after the other, adhering to the upper part of the conidiophore to form a loose head, pyriform, two-celled, slightly constricted at septum, at first hyaline, later rose, 12–22 by 8–13μ.

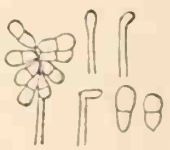

FIG. 128. — *Trichothecium roseum Link. Conidiophore and conidia, x 236.6*

Hab. Isolated from soil of plant-breeding plats, also from oat field in autumn and spring, Cornell University, Ithaca, N. Y., 1910–1911, by the writer. Plant pathology herbarium No. 5,922.

Mycogone nigra (Morgan).

Syn. *Monotospora nigra* Morgan, New North American Fungi. Jour. Cincinnati Soc. Nat. Hist. 18: 44. *pl. 3, fig. 20.* 1895.

Colonies at first hyaline, later showing yellowish tint, and finally becoming black-brown and zonate. In rapidly growing colonies, the hyphæ

near the margin are aerial as well as immersed and show a distinct yellow tint. Mycelium branched, septate, with numerous fertile branches bearing a single spore at the apex, 2–4.5μ thick; conidiophores varying from scarcely none to a length of 30μ, width 2–3.5μ, ascending or erect; conidia uniseptate, upper cell dark brown, smooth, thick-walled, globose, 12–15μ in diameter, lower cell hyaline to slightly colored, smooth, hemispherical, 8–10 by 9–12μ. Intercalary cells are often formed. Variations in which the lower cell is not cut off, and again when a second small cell is formed, occur in culture. All conidia may probably be considered as chlamydospores.

Hab. Growing on old cornstalks, Preston, Ohio, Morgan; a very common form in soil. Isolated repeatedly during fall, winter, and summer from cultivated soil, Cornell University, Ithaca, N. Y., by the writer. Plant pathology herbarium No. 5,923.

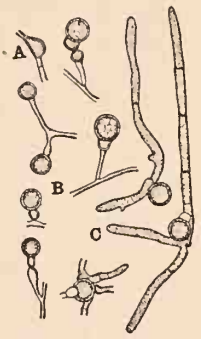

FIG. 129.—*Mycogone nigra* (*Morgan*). A, *chlamydospore, x 236.6;* B, *conidiophores and conidia, x 236.6;* C, *germinating conidia, x 236.6*

Dematiaceae

Torula No. 7 Hansen. Kohl, F. G., Die Hefepilze, 297. 1908.

In wort, this species produces 1 vol. per cent alcohol, does not invert cane sugar. In yeast water containing 15 per cent dextrose, it produces 5.3 vol. per cent alcohol. The temperature limits of growth are 0.5° C. and 38–39° C.

Hab. Found in soil beneath a grape vine, Hansen. Kohl, l. c.

Torula lucifuga Oud., Arch. Néerl. Sci. Nat. scr. 2, **7**: 294. *pl. 36, figs. 1–4.* 1902; Nederl. Kruidk. Arch. ser. 3, **2**: 916; Cat. Rais. Pays-Bas, 504. 1904. Sacc. Syll. Fung. **18**: 566. 1906. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 592. 1907.

Colonies orbicular, at first straw-colored, later with dark tints of many colors above (spotted), below olivaceous to black; vegetative hyphæ creeping, hyaline, nonseptate, variously flexuose and curved, branched, submerged in media, at length with single, later with two or more closely lying, septa, which form the conidial chains; conidial chains soon becoming dark-colored; conidia globose, ellipsoidal, or oblong, dark- or light-colored, contents full of small vacuoles, 10–22 by 8–10μ.

Hab. Isolated from humous soil from woods called Spanderswoud near Bussum, Holland, September, 1901, Koning.

Stachybotrys atra Corda, Icon. Fung. **1**: 21. *fig. 278 B.* 1837; Anleit., 64. *pl. B 18, figs. 5–8.* 1842. Sacc. Syll. Fung. **4**: 269. 1886. De Wild. et Dur., Prodr. Fl. Belg. **2**: 329. 1898. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 628. 1904–1907.

Colonies spreading, at first hyaline, becoming black with age, zonate in the center, margin entire; mycelium hyaline, septate, 5–6μ, with branches almost at right angles, with oval, ellipsoidal, or globose chlamydospores up to 12μ in diameter; articulate with age; conidiophores fuliginous near the apex, almost hyaline at the base, branched, septate, 65–75μ high by 2–4μ thick, slightly alternate toward apex, bearing on the summit a whorl of papillate basidia; basidia 10–12 by 4.5–5μ; conidia single, smooth, ellipsoidal, usually with acute ends and mostly with two oil drops, slightly colored when young to fuliginous and black when mature.

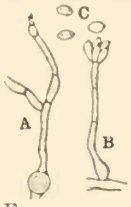

FIG. 130.—*Stachybotrys atra* Cda. A, *hypha with chlamydospores, x 236.6;* B, *conidiophores and basidial cells, x 236.6;* C, *conidia, x 236.6*

Hab. Isolated from arable soil, North Cohocton, N. Y., summer, 1911, by the writer. Plant pathology herbarium No. 5,924.

Stachybotrys cylindrospora n. sp.

Colonies round, thin, diffuse, becoming black with age; mycelium branched, septate, hyaline, 0.5–3μ; conidiophores hyaline at base, fuliginous toward apex, branched, septate, attenuate toward tip, 40–65μ high, bearing on the summit from 3–9 sterigmata; sterigmata subclavate, with or without short papilla, 8–11 by 4–5μ; conidia borne singly, smooth, subcylindrical to sometimes ovate, 6–16 by 3.8–5μ, hyaline when young, becoming fuliginous and nearly opaque with age.

Hab. Isolated from arable soil, North Cohocton, N. Y., August, 1911, by the writer. Plant pathology herbarium No. 5,925.

Coloniis rotundis, tenuibus, effusis, nigrescantibus; mycelio ramoso, septato, hyalino, 0.5–3μ; conidiophoris basi hyalinis, versus apicem fuligineis, ramosis, septatis, versus apicem attenuatis, 40–65μ in altitudine, apice 3–9 sterigmata ferentibus; sterigmatibus subclavulatis, cum vel sine papillula, 8–11 x 4–5μ; conidiis solitariis, levibus, subcylindricis vel ovatis, 6–16 x 3.8–5μ, primum hyalinis, deinde fuligineis et demum fere opacis.

FIG. 131.—*Stachybotrys cylindrospora. Conidiophore, basidial cells, and conidia, x 236.6*

Hab. In humis, North Cohocton, N. Y., Amer. bor.

Hormodendrum Hordei Bruhne, in Zopf's Beitr. 4: 1–42. *pl. 9.* 1894.

Colonies brown at maturity, circular, dense; mycelium brown, septate, branched, 3–6μ thick; conidiophores simple, septate, ascending or erect, 50–100μ; conidia various, some cylindrical with ends rounded, truncate, or subattenuate, others ellipsoidal, ovate, or subglobose, regular or somewhat angled, with age many become uniseptate and verrucose, 4–14 by 3–5μ, chains of conidia short.

Hab. Isolated from soil taken from oat field, Ithaca, N. Y., July, 1910, and experimental field in North Cohocton, N. Y., by the writer. Plant pathology herbarium No. 5,926.

The fungus has been cultivated on potato agar, gelatin, nutrient agar, and straw plugs. The conidiophores do not vary materially, and spores always show septa and are verruculose. Description is taken from fungus growing on straw plugs, gelatin, and nutrient agar.

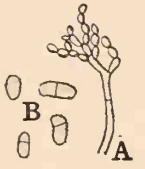

FIG. 132.—*Hormodendrum Hordei Bruhne.* A, *conidiophore and conidia, x 355;* B, *conidia enlarged, x 800*

Hormodendrum cladosporioides (Fres.) Sacc., Mich. **2**: 148. 1881.

Syn. *Penicillium cladosporioides* Fres., Beitr., 22. *pl. 3, figs. 23–38.* 1850.

Colonies olivaceous, round, dense; mycelium branched, septate, with age becoming articulate and guttulate, 2–5μ in diameter; conidiophores erect or ascending, branched, 100–200μ high by 3–5μ in diameter, olivaceous, toward apex gradually attenuate, ultimate branches copiously dividing with predominant tendency to dichotomy, septate, articulate above; conidia cylindrical to broad oval, olivaceous, 3–6 by 2.5–3.6μ, continuous or inferior ones rarely septate.

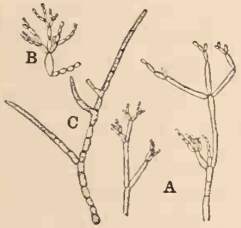

FIG. 133.—*Hormodendrum cladosporioides (Fres.) Sacc.* A, *conidiophores and conidia, x 236.6;* B, *ultimate branches of conidiophore, and conidia, x 236.6;* C, *old articulate hypha, x 236.6*

Hab. Isolated from oat field, July, 1910, and from plant-breeding plats, Cornell University, Ithaca, N. Y., November and December, 1910; and repeatedly by the writer during summer, 1911, at North Cohocton, N. Y., from the experimental potato plats. Plant pathology herbarium No. 5,927.

Hormodendrum pallidum Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 293. *pl. 34, figs. 1–3.* 1902; Nederl. Kruidk. Arch. ser. 3, **2**: 914. 1903; Cat. Rais. Pays-Bas, 506. 1904. Sacc. Syll. Fung. **18**: 581. 1906. Lindau, Rab. Krypt. Flora Abt. 8, **1**: 704. 1907.

Colonies orbicular, gray (Sacc. Chromot. No. 2), not plainly zonate; vegetative hyphæ creeping, articulate, partly thin with homogenous protoplasm, partly thicker with foamy contents; conidiophores erect, very light gray, upward dendroidly branched; primary and even secondary branches decussate, each succeeding branch and branchlet shorter than preceding, consisting of single cells, constricted at septa so as to make separation very easy; ultimate articulations small and serving as conidia, variable in size, 12–20 by 5–8μ.

Hab. Humous soil from Spanderswoud near Bussum, Holland, June, 1901, Koning.

Bispora pusilla Sacc., Mich. 1: 78. 1877; Fung. Ital. *pl. 21.* 1877; Syll. Fung. 4: 343. 1886. Oudemans, Arch. Néerl. Sci. Nat. ser. 2, 7: 292. *pl. 33, figs. 1–2.* 1902; Nederl. Kruidk. Arch. ser. 3, 2: 766. 1903. Lindau, Rab. Krypt. Flora Abt. 8, 1: 768. 1907.

Colonies spreading, black; vegetative hyphæ filamentous, partly submerged and partly superficial, brown-black, articulate; conidiophores erect, uniformly brown, with the exception of one or two cylindrical, short, and pale basal cells; conidia in simple or branched chains, elliptical, rounding at ends, rather thick-membraned, equally two-celled, not at all or slightly constricted at the septum, at first hyaline, then light brown, and finally dark brown, 9–12 by 4–5μ.

Hab. Isolated from piece of decaying wood in humous soil from Spanderswoud near Bussum, Holland, June, 1901, Koning; on decaying oak and willow from various places.

Stemphylium botryosum Wallr., Fl. Cr., 300. 1831. Sacc. Syll. Fung. 4: 522. 1886.

Syn. *Urocladium botrytis* Preuss., in Linnea 24: 111. 1851; Sturm Pilze 6: 83. *pl. 42.* 1851. Oudemans, Arch. Néerl. Sci. Nat. ser. 2, 7: 293. *pl. 35, figs. 1–3.* 1902.

Colonies very dark, orbicular; vegetative hyphæ creeping, very extended, thin, irregularly branched, at first hyaline, then becoming light brown and finally dark brown, septate, flexuose, more or less moniliform; branches ordinarily short, flexuose, simple or branched, hyaline or colored, more or less rough from the small abortive excrescences, simple or forked at the summit, and serving as support to the numerous conidia; conidia terminating the primary as well as the secondary branches, with short pedicel, sometimes nearly globose, sometimes elliptical or oblong, divided horizontally into 2–6 compartments of which one or several present a vertical or oblique septum, isabel-colored to brownish-black, 25–40 by 16–20μ; surface of conidia with age finely dotted.

Hab. Isolated from humous soil from woods called Spanderswoud near Bussum, Holland, September, 1901, Koning.

Alternaria fasciculata Cooke & Ellis.

Syn. *Macrosporium chartarum* Peck, Rpt. Bot., Rpt. New York State Museum 25: 93. 1873.
Macrosporium fasciculatum C. & E., Grev. 6: 6. *pl. 96.* 1877.
Macrosporium Maydis C. & E., l. c., 87.
Macrosporium Tomato Cooke, Grev. 12: 32. 1883–1884.

Conidiophores brown, erect or ascending, irregularly curved, solitary or cæspitose, septate, diameter uniform, 40–130μ long by 3μ wide; conidia dark brown, oblong ovate, minutely apiculate, 9–14μ wide by 35–90μ long, endochrome transversely 2–7 septate with usually several longi-

tudinal septa, the apical cell short or elongated into a straight, somewhat hyaline beak.

Hab. Fruiting freely in pure cultures; on dead leaves and decaying vegetable matter of all kinds. Isolated from soil of oat field and plant-breeding plats, Cornell University, Ithaca, N. Y., by the writer.

Alternaria humicola Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 292. *pl. 32, figs. 1–5.* 1902.

Colonies at maturity orbicular, black-green (Sacc. Chromot. No. 34); fertile hyphæ well developed, hyaline, articulate, 3-5μ in diameter, racemosely branched; conidia polymorphic, cylindrical, obclavate, oblong, lageniform, at first hyaline, later honey-colored, thin, dark, finally black-green and fuliginous, variable in size, maximum 16 by 50μ, 3–7 septate, muriform, in advanced age dense and very finely roughened, slightly or noneonstricted at septa.

Hab. Isolated from humous soil near Bussum, Holland, March, 1901, Koning.

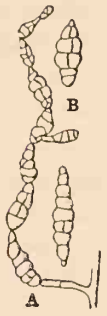

FIG. 134. — *Alternaria fasciculata Cooke & Ellis.* A, *conidiophore and conidial chain, x 236.6;* B, *conidia enlarged, x 533.3*

Stilbaceae

Stysanus difformis Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 296–297. *pl. 29, figs. 1–6.* 1902.

Creeping mycelium filamentous and hyaline; coremia gregarious, erect, dark olive, 2.5 mm. high by 120–220μ broad, with unequal wavy or often flexuose surface, thickened toward the base, toward the top sometimes producing a lateral branch, consisting of filiform, closely-united, septate hyphæ, which are intense avellanate in color; capitulum as regards form comparable to a deformed pileus that is depressed and has its margin repand or slightly incised, of the same color as the stipe, consisting of slender, filiform, fertile, septate, once- or twice-dichotomously-branched hyphæ, which are hyaline downward and avellanate olivaceous upward; branches septate, at the top producing the conidia; conidia globose or short elliptical, intense avellanate, 2.5–3μ in diameter, united in chains.

Hab. Found on decaying wood from humous soil of forest of Spanderswoud near Bussum, Holland, May, 1901, Koning.

Tilachlidium humicola Oud., Arch. Néerl. Sci. Nat. ser. 2, **7**: 297–298. *pl. 12, figs. 1–7.* 1902.

Tufts orbicular, snow-white, woody; primary threads ascending, cylindrical, 35–40μ thick, composed of very slender little fibrils (filaments) that are articulate, hyaline, and closely united, surrounded on every side by secondary basidiomorphic filaments; basidiomorphic filaments 40–80μ high, diverging, simple, continuous, flexuose, arising from the primary threads, subclavate; capitula of conidia globose, terminal, 15–18μ in

diameter, distended with gelatin, at length on drying becoming condensed; conidia light green, oblong or ovoid, 6–7 by 3–5μ.

Hab. Isolated from humous soil from forest of Spanderswoud near Bussum, Holland, May, 1901, Koning.

SUMMARY

The fungous flora of the soil is taken to consist of obligate saprophytes and facultative parasites. The former are by far the more abundant in the soil.

Many facultative parasites can be directly isolated from the soil, as shown by the isolation of *Colletotrichum* sp., *Fusarium* sp., *Macrosporium* sp., *Helminthosporium* sp., by Beckwith; *Pythium de Baryanum* Hesse, by Butler; *Rhizopus nigricans* Ehren., by Hagem and by the writer; *Trichoderma Koningi* Oud., by Oudemans and by the writer; *Trichoderma lignorum* (Tode) Harz, *Trichothecium roseum* Link, *Fusarium oxysporum* Schlecht. (*Fusarium orthoceras* Appel), and *Hormodendrum Hordei* Bruhne, by the writer.

Some facultative parasites are very widely distributed, as is shown by the isolation of *Rhizopus nigricans* Ehren., *Trichoderma Koningi* Oud., *Pythium de Baryanum* Hesse. All three species have been isolated in Europe. The first two have been isolated by the writer at Ithaca, N. Y. The last-mentioned species is known to be generally distributed in the United States, although it has not been isolated.

The isolation of soil fungi, because of specialization as to food, temperature and moisture requirements, and aerobic or anaerobic conditions, requires different technic and media.

A fungus should not be considered as belonging to the soil flora unless it has been directly isolated or has been shown under control experimentation to live in the soil. Control experimentation consists in growing a crop from absolutely clean seed in sterilized and nonsterilized soil, all other conditions being identical. This latter method of proof has shown, so far as the "Wurzelbrand" of sugar beets is concerned, that *Phoma Betae* Fr. winters on the seed balls and not in the soil, while *Pythium de Baryanum* Hesse and *Aphanomyces laevis* de Bary winter as saprophytes in the soil and not on the seed balls.

The history of the study of the fungous flora of the soil consists of two definite lines of study: one line consists of an isolation of soil forms in order to obtain a knowledge of the forms themselves prior to making biochemical studies, and also to obtain a knowledge of the habitat and the distribution of the species; the other line consists in obtaining a knowledge as to whether a facultative parasite does or does not live over winter in the soil.

Failure of the writer to isolate Rhizoctonia from Long Island soil that was growing a crop of diseased potatoes may be explained on either of the two following grounds: the fungus does not live as a saprophyte in the soil, but is carried over winter on the seed; or the fungus may have been overgrown in the plates by more rapidly growing species, such as some of the species of Mucor or Fusarium. Species of both genera were present in the plates.

Soil three months after application of sulfur yielded the same species of fungi as did the soil that had had no such application.

The taxonomic considerations include the presumable facultative parasites of the soil, with references to literature but no descriptions; and the obligate saprophytes that have been isolated from the soil thus far, together with standard descriptions. The whole includes some one hundred and thirty-two species and varieties.

CONCLUSION

The need is urgent for a study of the fungi in soils generally recognized as sick to some particular crop, as well as of the relation of these fungi to crop rotations, fertilizers, and fungicides. Do not the debris of the crops in the rotation serve as excellent pabula for the fungi that produce the disease in question? Which crops are of this nature? What effect on the soil fungi results from the addition of various kinds of fertilizers? Is the application of fungicides such as sulfur effective in changing the fungous flora? If so, in what way? These are but a few of the questions that need elucidation.

More should be known of those fungi generally recognized as facultative parasites. Are not some of the species carried over from year to year on or in the seed, or do they live as saprophytes in the soil during the winter? Too often it is said without the proper evidence, that a fungus is a soil organism. The ease with which error can be made is shown by the fact that, with the exception of the past two or three years, since 1895 *Phoma Betae* Fr. has been considered as living in the soil in sugar beet sections. It is now quite conclusively demonstrated to be carried over on the seed balls and not in the soil. It seems to the writer that if a more detailed and far-reaching study were made of this phase of the question, it would be far more remunerative in many instances than a study of the control alone, after fungi have made a sick soil.

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